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REVIEW OF WORLD ENGINEERING PROGRESS

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A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *ANTI-BACKLASH GEARING*

For miniature speed changers such as are used in automatic control gear and the like, an anti-backlash gearing has been developed which embodies two parallel reductions to form a locked train through a torsion spring between the gears on one countershaft. Tension in the spring just exceeds the maximum torque which the unit is expected to transmit. Play or backlash is taken up by each gear mesh since the torsion produced by the spring is reflected through all gear meshes in the closed loop. Spring deflection does not change except to compensate for inaccuracies in the train. If the high-speed shaft is rotated in the clockwise direction, all useful output torque will be transmitted through No. 1 countershaft, while No. 2 countershaft does not transmit useful torque but absorbs energy and lowers efficiency to the extent that the gears are operating under the load imposed by the spring. When the gearing is operated in the reverse direction, the output is transmitted through the spring and gears of No. 2 shaft. Transmission is positive up to the point of torque equal to the pre-tension on the spring. At that point the gears on the No. 1 countershaft are not operating under load. Higher torque transmission takes up the backlash in the opposite direction and the anti-backlash feature does not function because of the lost motion in taking up the backlash. In multiple sections of these double-reduction units, the springs in the higher-speed sections are wound to a lesser degree corresponding to the torque transmitted through them. In applying this type of gearing, it is important to have an input torque which is large enough to overcome the losses and roughness inherent in the preloaded gearing. The higher the ratio of the gearing, the less noticeable is the input friction and roughness at the high-speed end.

● *WATER-COOLED MERCURY ARC LAMP*

The life of high-intensity mercury arc lamps of the water-cooled type, such as are used as a light source for micro-projection purposes, is comparatively short. Moreover, before the lamp fails completely, the light intensity decreases substantially after a comparatively short period of use. This decrease in light intensity is due to the formation of a coating on the quartz tube in which the arc is formed. The explanation for this is uncertain. But it is at least known that this coating is not due to impurities of the kind usually encountered in tap water, because even when distilled water is used, the same type of coating is formed on the quartz tube. It is believed that due to the high voltage at which these lamps operate, ionization of the cooling water takes place, which renders the water highly reactive. This may lead to the formation of various compounds while the water flows through the circulating system of the lamp. These compounds may possibly include metal carbonates, produced by reaction between water, carbon, oxygen, carbon and oxygen-containing compounds in the water and the metal walls of the cooling system. Once such a reaction has taken place, the compounds are deposited on the quartz tube. The surprising discovery has now been made that by passing the cooling water through a mixture of anion and cation exchange resins, formation of a coating is minimised, if not completely suppressed. In practice, the water treatment is realised by circulating the water in a closed circuit incorporating a vessel which contains the ion-exchange material.

● *HIGH-WEAR RESISTANCE MATERIALS*

In spite of its utmost importance in engineering problems, a better understanding of the real mechanism of the wear of metals is still lacking. In fact, the vast mass of empirical data extant has resulted in a number of unrelated and even conflicting statements, some true, some half-true, some perhaps not true at all. Logical approach to the problem leads to the conclusion that the ability of a surface to deflect out of the way of asperities on a moving mating surface or foreign particles and to spring back again seems to be important in wear resistance. Large amounts of elastic deflection may be achieved by the selection of a material which has high strength and hardness and a low modulus of elasticity. This desirable combination of properties does not commonly occur in metals, but both the elastic limit and the modulus of elasticity of metals can be controlled within certain limits. Thus, there exists for the future considerable latitude in increasing the total elastic deflection of metals or related materials with a view to increasing their wear resistance. The correctness of this concept of wear resistance is borne out by the fact that materials which are normally considered abrasive possess excellent wear resistance. This has been proved by tests conducted on cylinder liners of

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alundum. In addition to freedom from liner wear, the wear rate of the piston rings was also found to be greatly reduced. With economical methods of manufacturing alumina wearing surfaces, this material may therefore become generally accepted for this and other purposes.

● *MAGNETIC-DRIVE PUMP*

A magnetic-drive pump in which the liquid pumped is completely isolated and confined to the wetted end, and which presents no rotating connection whatsoever between the driven pump end and the liquid pump, has now become commercially available. The complete sealing-off of the liquid end of the pump is accomplished by using a true magnetic drive. Power is transmitted from motor to pump by employing the simple principle of matching magnetic fields, from adjacent opposite poles, mounted around the periphery of the driving and driven elements. A circular disc, with 12 to 24 permanent magnets (depending upon pump size) is attached to the rotating motor shaft; this drives a corresponding permanent magnet disc and impeller unit, which is attached to and rotates around a stationary shaft in the liquid end of the pump. No physical connection exists between the driving magnet and the driven magnet. As a result, a non-magnetic diaphragm can be, and is, employed completely to separate the driven or liquid end of the pump from the driving end of the pump. Because of this separation, and because no rotating connection is maintained between the two ends, liquids being pumped in the liquid end are confined to that end and cannot escape from it. Hence, leakage is said to be eliminated completely. Applications of this type of pump are expected to centre around processes where a closed system of liquid flow is necessitated, where contamination to the liquid-bearing pump cannot be tolerated, or where leakage of the liquid handled is not permissible. The new design suggests important uses on liquid lines handling hazardous, toxic or odoriferous liquids, and for pumping extremely hot or cold liquids as well as those with highly corrosive properties.

● *ALUMINIUM COATING OF STEEL PARTS*

A method for the dip coating of fabricated steel products with aluminium is now in successful commercial use. The dipping process is carried out in a bath of molten aluminium, on top of which floats a layer of molten salts, which must be penetrated by the piece to be coated before it can come into contact with the molten aluminium. The salt bath performs a multiple function, i.e., (1) to preheat the work to the aluminium coating temperature, (2) to flux the work, (3) to scavenge the bath, (4) to prevent oxidation of the aluminium bath and (5) to aid in draining off any excess aluminium after coating. In order to preclude contamination of the bath by the material of the container, a porous inner layer of bricks is built up in the steel shell of the container. When the latter is filled, salt permeates the brick and provides a furnace lining with the active salts used in the process. The bath is kept at a temperature of some 1400° F by means of immersed electrodes or by induction heating. In a typical bath a salt layer of 12 in. is maintained above a bath of molten aluminium 12 in. in depth. Immersion time varies with the intended service of the processed piece and, where a fairly heavy layer is desired, an immersion time of 4 to 6 minutes may be used. The molten salt layer protects the newly coated part on removal. Various methods are available for removing any excess aluminium that may have adhered to the piece after withdrawal from the salt bath. The film of salt remaining on the aluminium after solidification is removed in a water rinse.

● *MECHANICAL STRESS RELIEVING*

It is well known that thin iron and steel sheet or plate is apt to show unevenness which may have been caused, for instance, during rolling, by the disposition of the rolls or by uneven cooling when hot rolling. These distortions, which are due to internal stress in the material, can be relieved, and the material straightened, merely by tapping or hammering the piece. This process is often the only practical means to relieve the internal stresses. In the majority of cases, tapping is done by hand, as, for instance, in the manufacture of circular saws, in which case every saw must be tapped flat before it can be considered a finished product. This highly skilled and exacting task is usually carried out by specialists, commonly known as "saw doctors," who by visual examination are able to tell at which place tapping is required. In a recent patent it has now been proposed to do away with all this specialised work and to replace the human skill by a machine. The inventor bases his proposal on the principle that where no internal stresses exist, tapping has no practical influence, but at the point where internal stresses exist, tapping will relieve them. To obtain stress relief in a surface, the inventor therefore employs a machine which taps, hammers, or presses the area to be treated at a number of points with a force sufficient to release the stresses but incapable of effecting a change in dimension, as, for instance, thinning of the sheet.

● *NEW PERMANENT MAGNETIC MATERIAL*

It is reported that a magnetic material prepared from bismuth and manganese has been developed which possesses a coercive force of 3,000 oersted, the highest recorded coercive force of any known permanent magnetic material. Because of its high coercive force, this material exceeds any other permanent magnet, excepting the platinum-cobalt alloy, in available flux density

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in short magnets in which the length-to-diameter ratio is unity or less. As magnets of the new material are made by powder metallurgy technique, complicated shapes can be made to close tolerances without requiring machining. The new material is the outcome of a search for a magnetic material containing neither nickel nor cobalt, and it was chosen because of its potentially high magnetic anisotropy. The interesting fact is that both bismuth and manganese are non-magnetic by themselves. In the preparation of the magnetic alloy, powdered manganese and powdered bismuth are mixed and heated to about 700° C and aged at that temperature for from 8 to 16 hours. The alloy then consists of the intermetallic compound manganese-bismuthide and unreacted manganese and bismuth. To separate the enriched bismuthide from the mixture, the material is ground and, by means of a magnetic separator, the non-magnetic particles are then separated from the non-magnetic residue. The magnetic portion is then hot-pressed at a temperature of 300° C in a double-acting floating die in the presence of a strong magnetic field.

● *X-RAY GAUGE FOR CHECKING TUBE THICKNESS*

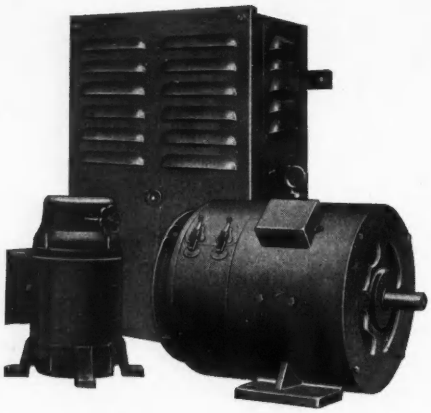
In the manufacture of seamless pipe, the cutting-off or cropping of the ragged, irregular ends inherent in the manufacturing process is an important finishing operation. Excessive eccentricity near the ends of the pipe causes wall thickness variations, and any area which falls below the minimum wall thickness must be cut away. In practice, the correct crop length may vary in a single rolling from a few inches to several feet. Without an accurate device to determine the wall thickness, cropping becomes a hit-or-miss proposition, and at that often a costly one. If insufficient crop is taken, the pipe must be recut, which increases cutting time, while if overcut, the extra crop represents a waste of good material. It is reported that one producer of seamless pipe has obtained satisfactory results with the employment of X-ray operated gauges in determining correct crop length. These instruments are described as high-precision, non-contact, continuously indicating electronic micrometers, which check wall thickness and automatically mark undergauge areas for determining the crop point. It is claimed that wall thicknesses from 0·05 in. to 1·5 in. can be determined with an accuracy of 1 per cent. The equipment consists of a generator and a pick-up unit. The generator radiates an X-ray beam through the pipe wall, which is received by the pick-up unit passed into the open end of the pipe. The signal received actuates a servomechanism which sprays paint on the pipe at any point where wall thickness is less than the predetermined standard, thus making it possible to select the correct point for cropping.

● *FUTURE OF HOT-PRESSING POWDER METAL*

Remarkable progress has been made in recent years in the use of hot-pressing as a production tool in powder metal technique. It must not, however, be overlooked that so far no hot-pressing process has been realised which allows the rapid commercial production of hot-pressed powder components. At the same time, hot-pressing is proving exceptionally successful in a number of applications which involve costly materials and where processing cost is not decisive. An outstanding example in this respect is the production of diamond tools for dressing, grinding, and drilling. The technique of hot-pressing generally follows one of two procedures, namely hot-forging or hot-moulding. In the first method, cold-pressed and sintered parts are removed hot from the sintering furnace and subjected to a forging operation. In the second method, pressing and sintering are performed simultaneously in one operation. Recent developments indicate that hot-pressing may become a most valuable tool for the production of high-temperature alloys and metal-ceramic materials. After considerable work, a method has recently been evolved which allows the production of a hot-pressed alloy possessing high temperature stress-rupture values equal to those of the forged product. As a next step, a process was worked out whereby certain materials and grain orientation are introduced which are an impossibility when starting from a cast ingot. The success of the new method can be gauged from the fact that the modified alloy obtained in this way showed a stress-rupture life some five times that of a forged material.

● *CERAMIC COATINGS*

The last ten years or so have witnessed considerable progress in the application of ceramic coatings to metal parts exposed to high temperatures for the purpose of protecting these parts against the corrosive attack by air or combustion products. In spite of frequent reports announcing spectacular results, no final solution to the problem appears to be in sight as yet, and in a number of cases service results are definitely contradictory. This is not altogether surprising when it is considered that conditions of exposure will never be quite the same ; also, owing to the methods used for the application of the coating to the base material, it will be difficult to produce coatings of absolutely equal density and uniformity. Among outstanding difficulties in the way of ensuring unfailing protection of the underlying material are, of course, the elimination of porosity of the coating and its adherence to the parent material regardless of differences in thermal expansion, the occurrence of thermal shocks, hot spots, and so on. The continuing shortage of such alloying



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elements as niobium, cobalt and tungsten, which are especially important to the production of jet engine components, has not failed to stimulate the quest for improved ceramic coatings. At the same time, it appears that it is now being realised that ceramic coatings must not be expected to provide complete protection as was hoped in the early stages of development. The present-day attitude, therefore, is to develop coatings which, for a given temperature level, will prolong the life of highly alloyed materials to a reasonable extent or will ensure equal service life for a material of somewhat lower alloy content. It is gratifying to note from recent reports that, on this basis, considerable progress has been recorded.

● *BONDING RUBBER TO ALUMINIUM*

A relatively new method of bonding natural or synthetic rubber to aluminium is attracting considerable attention. This process, which puts the combined properties of aluminium and rubber at the disposal of the designer, requires a minimum of surface preparation, and either natural or synthetic rubbers may be bonded to similar or dissimilar surfaces at temperatures which are sufficiently low to prevent deterioration of the rubber. Also, the process can be completed at pressures which do not unduly distort even soft rubber. The bonding agent is a modified phenolic resin used in conjunction with a polyvinyl formal powder. The resin is applied in the form of a free-flowing emulsion, together with the polyvinyl formal powder hardener, to both the metal and rubber surfaces after these have been prepared. The respective surfaces are first degreased and then given a pretreatment dip in a mixture of chromic and sulphuric acids. The rubber to be bonded must be cyclized by surface immersion in concentrated sulphuric acid. This results in the hardening of the outer skin of the rubber and the production of a multiplicity of fine fissures on the surface, which materially assist the adhesion of the bonding resin. About one hour after the bonding agent has been applied, the surfaces are brought together under light pressure and subjected to dry heat at 110 to 120° C for a period of 20 minutes. By means of an accelerator, which is added to the resin emulsion, and by increasing the temperature up to 150° C, it is possible to reduce the curing time to five minutes. But joints so produced are slightly deficient in strength.

● *SUBMERGED COMBUSTION*

In submerged combustion, a gas or oil fuel burner of special design is placed in the liquid to be heated or evaporated, and fuel and combustion air are supplied at a pressure sufficiently high to enable the products of combustion to overcome the static pressure produced by the liquid. The escape of the combustion gases, therefore, takes place in the form of gas bubbles rising through the liquid to its surface, and as each gas bubble is scrubbed by the surrounding liquid, an excellent rate of heat transfer to the liquid is obtained. Submerged combustion, therefore, dispenses with metallic heat transmitting surfaces, and it is this feature which at one time raised the hope that this system might cause a revolution in steam-raising technique. These expectations did not, however, materialise for the reason that the steam is commingled with the waste products of combustion so that condensing operation is not feasible. Also, the pre-compression of the combustion air and of the fuel, if a gas is used, consume a considerable amount of power and require expensive compressor plant. Submerged combustion has, therefore, never attained more than occasional applications. Noteworthy among such uses is plant for the heating of corrosive acids which, in the case of orthodox heating plant, would require highly expensive heat exchangers. The interesting proposal has recently been made to evolve a back-pressure type internal combustion engine plant in which the gases are rejected into the liquid to be heated. This arrangement would do away with the need for a compressor plant and could be used to generate by-product power.

● *NEW TECHNIQUES FOR PRODUCING METALS*

The claim has been made by a prominent chemical concern that the cost of producing metals can be drastically reduced by new techniques. These techniques involve the treatment of ore concentrates by chemical methods instead of the usual smelting and refining techniques employed to produce pure metals. It is considered that while the new process will not necessarily immediately lead to lower metal prices, owing to prevailing shortages, the reduced production cost will, no doubt, permit the economical mining of ore bodies with lower metal content. In fact, pilot plant results indicate that production costs from ore concentrates to pure metals should be considerably below current costs of production by conventional methods. The first large-scale plant to embody the new technique will be one for the refining of cobalt, an annual production of 2,000 tons of cobalt being envisaged. A development which may soon find commercial application is a new process for the production of pure copper powder from any form of copper scrap, brass scrap or blister copper. This process is claimed to achieve virtually 100 per cent extraction. The product, which is said to be better than 99·9 per cent pure, meets all standards for oxygen-free, high-conductivity electrolytic copper. It is expected that costs of scrapping existing facilities in many cases can be recovered in about three years owing to the lower production costs. Another interesting aspect is that during treatment, the different metals in the ore are produced separately as pure powders. The reagents used are generally recovered.

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THE ENGINEERS' DIGEST
REVIEW OF WORLD ENGINEERING PROGRESS
VOL. XIII. No. 9. SEPTEMBER, 1952

S.B.A.C. Flying Display and Exhibition

THIS year we have witnessed a display of a rare vintage, even among the remarkable galaxy of S.B.A.C. post-war displays. The S.B.A.C. is hard on its members and under its rules no aircraft without some novelty can be shown for more than 2 years. This time, so much that is fundamentally new has appeared that the record-winning "Canberra" bomber and the public-winning "Comet" airliner have almost "disappeared" into familiarity.

Some new principle distinguishes almost every aircraft shown for the first time this year. Breaking every rule and precedent, the Avro 698 practically proceeded from its first flight (on the 30th August), to the Farnborough demonstration. It is the first large (4-jet) delta wing military aircraft and the first prototype (other than research machine) to dispense with the tail plane altogether. The faith of the makers in submitting a prototype so early to public view, and the confidence of the authorities in ordering a number of these machines "off the drawing board" are significant. They suggest that by flying research aircraft of this configuration, the earlier dangers associated with some phases of their flight have been eliminated and their high-speed advantages can now be enjoyed without fear. The flights of this aircraft seen last week seemed to vindicate the trust put in this development.

The second major event at the display was the demonstration of supersonic flight. The drama was heralded by suitable sound effects (the "sonic bang") produced in a certain manoeuvre when returning from beyond the sonic barrier. Of the fighters shown for the first time, the single-(jet) engine (Rolls-Royce Avon) single-seater Vickers Supermarine Swift is the logical and strong link in a line of fighter development which has been evident since the general acceptance of the swept wing.

Compared with other "firsts," the demonstration of the "Swift" at an S.B.A.C. display is somewhat retarded; but it has already consolidated its position in the pattern of the Air Force by its inclusion in the "super-priority" list of military aircraft. Also on this list is the de Havilland 110 twin-engine (Avon) two-seater all-weather fighter. This machine has swept wings and a twin-boom tail structure, which has been a hall-mark of de Havilland fighters for some years. It is this aircraft which was announced to have flown faster than sound and was allowed to demonstrate its speed at Farnborough. Moreover, it is the first two-seater machine in the world to have achieved this distinction.

Two Armstrong Siddeley "Sapphire" turbo-jets drive the Gloster Javelin two-seater all-weather fighter, another newcomer to the display. Its novelty is the delta wing, though its fuselage and tail structure are conventional. Manoeuvrability rather than speed is its outstanding claim to distinction in performance.

The great events in civil development are the emergence into the flight stage of the graceful and stately Saunders-Roe Princess flying boat powered by ten Proteus turbo-propeller engines and of the Bristol Britannia. The latter is scheduled for operation by B.O.A.C. for long stages. It has an all-up weight of 140,000 lb and is powered by four Proteus engines developing 15,000 hp. Its cruising speed will be 380 mph and alternative seating capacities between 51 and 104 are envisaged. The Britannia is Britain's challenge to the future improvements in the existing long-range transport planes of U.S. origin. In lay-out, this aircraft is the most conventional of the new arrivals. Silence and efficiency are its sales points.

After two years, helicopter development is manifest again. The British-built Westland S55 of Sikorsky design was shown, and a milestone in helicopter development, particularly for passenger transport, has been reached with the flight of the Bristol 173. This is the first twin-engined helicopter (Alvis Leonides) built in this country. Twin-engine reliability is the major requirement for inter-city transport. The 173 is also the first British twin-rotor tandem helicopter. It has a fuselage which looks business-like to an airline operator, and can accommodate 10-13 passengers and even more in special cases.

First engine appearances are equally numerous for a single year. The Armstrong Siddeley "Adder" is the smallest British turbo-jet (1000 lb thrust) weighing only 580 lb. The Armstrong Siddeley "Viper" is a further development of the "Adder" for applications where a relatively cheap and expendable turbo-jet is needed. The Napier "Eland," a 3000 hp turbo-prop engine of only 36 in. diameter, appears to be the final

(*Concluded on page* 318)

Temperature Measurement on Components Rotating at High Speeds

By E. Fournel and C. Douchet. (From *La Recherche Aéronautique*, No. 27, May-June, 1952, pp. 33-38, 3 illustrations.)

For measurements on rotating parts, it is generally necessary to transmit voltages or electric currents from the rotating member to a stationary apparatus by means of sliding contacts. Temperature measurement with thermocouples and sliding contacts is a typical application, and from the information so far published it does not seem that the problem has been satisfactorily solved, particularly for low temperatures and high running speeds.

In fact, under such conditions, the low intensity currents going through the contacts may be affected by disturbances which make it impossible to obtain reliable indications. The procedure developed by C. Douchet, of the Heat Exchange Laboratory of O.N.E.R.A.*, uses sliding contacts of an improved design in conjunction with a measuring circuit which overcomes these difficulties.

Before describing this new method, it will be of interest to review the principal methods used in industry for the assessment of temperatures on rotating or reciprocating parts.

Industrial Procedures for Indication of Temperature of Moving Parts.

Thermo-colour indicators: Some substances have the property of altering their colour owing to chemical reactions which take place in them at determined temperatures. The colour is maintained after cooling down to room temperature. The use of these substances requires certain precautions in regard to the preparation of the surfaces to be coated, the time of exposure to heat, etc.

Frequently, the same product can be employed to give two, three or four different colours, each of these corresponding to a well-determined temperature. This method can be used up to about 800° C and indications are accurate to approximately ± 5 per cent.

Fusible elements: With this procedure, pure or eutectic substances having a known melting point are inserted in recesses arranged at the measuring positions on the part being investigated. The range of temperatures covered is only up to about 500° C. When the fusible elements are well grouped together, an experienced operator can determine temperatures with an error of about 5° C. The indicated temperatures are generally on the low side. The "Tempil" fusibles (Tempil-sticks), recently put on the market in America, and available in the form of plastic substances, varnishes, or pencils, cover the range 45-1093° C.

Ball-hardness tests: This procedure is applicable only if the investigated part consists of certain alloys which can be subjected to an appropriate thermal treatment. The hardness number of these alloys varies according to the maximum temperature reached during a sufficiently long period of time. The procedure can be used to determine approximately the maximum temperatures occurring on pistons, exhaust valves, etc. The error is between 5 and 15° C. This method is used when no other, more practical, methods are available.

New Method of Measurement with Sliding Contacts.

The improved method with sliding contacts enables temperature measurements with thermocouples to be obtained with an accuracy of ± 1° C. The method can be applied generally, for the measurement of phenomena generating relatively low voltages.

In general, the sliding contacts include slip-rings, mounted on the rotating component under investigation, and stationary brushes, of graphite or graphite powder, which are pressed against the slip-rings by springs. At peripheral speeds above 50-65 fps, this arrangement is no longer suitable for measuring low current intensities or low voltages (of the order of a micro-ampere or of one millivolt). The defects then observed are as follows:—(i) considerable contact resistances and contact resistance variations (vibration of the brushes), (ii) spurious voltages generated by thermo-electric currents due to unequal heating of the brushes, and (iii) fairly rapid wear of the brushes.

In order to reduce the contact resistances, some experimenters have tried to obtain a high natural frequency for the brush vibration as compared with the brush rotation frequency. This led to the use of extremely stiff restoring springs, and resulted in the production of parasitic voltages of up to one millivolt, which precluded the use of this modification for thermocouples.

The basic principle of the improved arrangement can be summarised as follows:—The usual brushes and springs are replaced by contacting elements consisting of packs of fine metal wires held together by means of a cellulose glue. This glue after drying still has a certain amount of viscosity which contributes to the damping of vibrations.

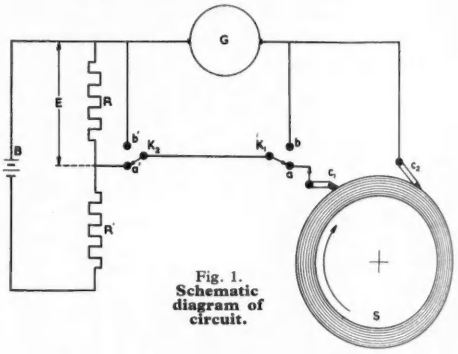

Fig. 1. **Schematic diagram of circuit.**

A schematic diagram of the measuring system is shown in Fig. 1. The battery B is connected to a potential divider consisting of a fixed 1-ohm resistance R and an adjustable resistance R' of some 10,000 ohms. The measuring instrument is a galvanometer G, giving a scale deflection of 150 mm for a potential difference of 450 μV, with a consumption of 7·5 μA. The circuit also includes two change-over switches K_1 and K_2, and the brush arrangements C_1 and C_2 rubbing on the rotating slip-ring S.

The measuring procedure is in three stages:—(i) Preliminary adjustment of the voltage E across the terminals of the fixed resistor R. Switch K_1 is set at the position b, and K_2 at a'. The resistor R′ is then adjusted until a value of about 360 microvolts is obtained, which is of the order of magnitude of the e.m.f. subsequently transmitted by the sliding contacts.

(ii) Measurement of the voltage E with the sliding contacts included in the galvanometer circuit. For this measurement, which determines the thermocouple voltage, the switch K_1 is set at a and K_2 is at a'. In this way, the difference in readings ΔE is obtained,

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which represents the overall error due to the transition resistance and the parasitic e.m.f. of the sliding contacts. The value of ΔE depends on the galvanometer resistance.

(iii) Measurement of the parasitic e.m.f. "e" of the sliding contacts. The switch K_1 is set at a, and K_2 at b'. The values of ΔE and e serve to determine the contact resistance r.

DESCRIPTION OF SLIP-RINGS AND CONTACTING ELEMENTS.

Slip-rings: After investigating slip-rings of various materials, it was decided to use slip-rings of pure silver, since these gave the best results in tests at 12,000, 16,000 and 23,000 rpm, corresponding to peripheral velocities of the slip-rings of 165, 220, and 312 fps, respectively.

Before each test, the rubbing surface of the slip-ring was carefully polished with " 00 " grade emery paper. After this the rubbing surface was roughened with the same paper applied in the crosswise direction (i.e., along the generator lines of the cylinder) until the initial polish disappeared. This operation serves to improve the running-in conditions of the contacting elements.

Contacting elements: Like the slip-rings, the wires of the contact brushes must be of pure silver. After extensive tests, it was possible to determine the optimum characteristics as follows :—

The contacting elements are designed as shown in Fig. 2. Each contact brush consists of 15 wires of 0·20 mm diameter and 15-20 mm long, maintained against the slip-ring with a constraining moment of 25 gr cm.

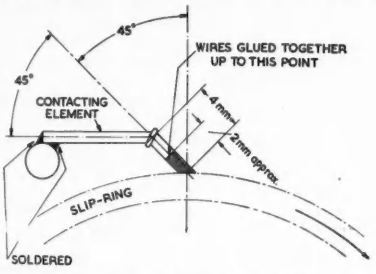

Fig. 2. Details of contacting elements.

The contacting elements are constructed in the following manner. The wire pack is cut to the required length with one end slanting at a suitable angle and is then held tight with a fairly thin metal wire. The brushing surface is made as flat as possible by tapping the pack lightly against a flat surface. The other end is then soldered at right angles to a small cylindrical shaft which has been previously tinned. The metal wire around the pack is replaced by a binding at about 4 mm from the free end in order to prevent the spreading of the wires. The wire pack is then covered with a cellulose glue, such as " Durofix," up to about 2 mm from the free end. After drying, the contacting element is given its final shape by bending it at the level of the binding. The small-diameter shaft soldered to the contact brush is arranged in a carrier unit so that it can pivot freely. A sewing thread supporting an appropriate weight is fastened to and wound round the shaft. The contacting element is thus pressed against the slip-ring with the required load. A flexible copper wire of small diameter, shaped as a helical spring, is used to connect the contacting element without any appreciable restoring force to a fixed terminal on the carrier, which is connected to the external leads.

RESULTS OF TESTS.

Parasitic e.m.f.: During a first test with continuous running for 125 hours at 12,000 rpm, and the slip-ring transmitting 6 μA, the parasitic e.m.f. remained extremely low and never exceeded 18 μV. In a second test of 31 hours at the same speed, the e.m.f. first reached a maximum of 30 μV and subsequently remained at lower values.

The first test was made with two separate contacting elements, whereas the second was carried out with four contacting units spaced at 90 degrees around the slip-ring, with diametrically opposite elements connected in parallel. Further tests showed that the parasitic e.m.f. is not appreciably affected by the vibrations of the mounting arrangement, slip-ring eccentricity, or running speed, within the range of speeds tested, i.e., between 12,000 and 23,000 rpm.

As sliding contacts are also used for the indication of rapidly-varying phenomena, the parasite e.m.f. was studied with the aid of a cathode-ray oscilloscope. This unit was sufficiently sensitive (screen deflection of 1 cm/mV) to detect easily any e.m.f. of 100 μV. It was found that after the initial running-in period, no spurious signals appeared on the screen.

Contact resistance: The contact resistance was also investigated during the above tests. In the first test, the contact resistance r reached approximately the following values :—

beginning of test : $r = 1$ ohm,
after 54 hours : $r = 6$ ohms,
after 125 hours (end of test) : $r = 12{\cdot}5$ ohms.

During the second test, the contact resistance remained more or less constant at considerably lower values, i.e., below 2 ohms. To confirm this decrease in resistance with four contacting elements per slip-ring, the second element of each group was repeatedly switched out of the circuit during this latter test. This resulted in an immediate increase in resistance of 3-4 ohms. A summary of the values of contact resistance obtained for various values of transmitted current is given in the following table.

Running time	Transmitted current (μA)				
	3	10	100	1000	10,000
	Contact resistance (ohms)				
5 min.	0·01	0·09	0·08	0·06	0·05
9 hrs.	0·8	0·75	0·65	0·45	0·3
18 hrs.	2·3	2·2	1·65	1·17	0·68

These results show that, with a current of the order of a few milliamperes, the wear of the contacting elements gives a smaller increase in contact resistance than at lower current intensities.

The tests also indicated that the contact resistance is affected to a greater extent by the vibrations of the supports of the contacting elements than by the slip-ring speed. The following table gives the values of contact resistance obtained after a running period of 11 hours at different speeds, using separate contacting elements.

Slip-ring speed rpm	Vibration amplitude mm	Contact resistance after 11 hours (ohms)	Remarks
12,000	0·02	2·5	natural vibration frequency
17,700	0·015	2·0	
23,000	0·090	20·0	
12,000	0·05	5·0	unbalanced pulley

Length of running time: In e.m.f. measurements, the magnitude of the error due to contact resistance depends on the current flowing through the circuit and is therefore affected by the resistance of the millivoltmeter used. In measurements of potential difference, however, this resistance has practically no effect on the measuring error. The best results as regards low values of contact resistance over a long period of operation were obtained with the parallel-connected contacting elements in the second test which extended over 31 hours.

Various additional modifications were tried. For instance, the rubbing surface was lubricated by means of auxiliary brushes of graphite or carbon-silver. Silver amalgamation of the slip-rings was tried, but did not give a lasting improvement. In the end, it was found preferable to retain the original arrangement.

It should be noted that ring eccentricity is an important factor as regards the rate of wear of the rings. Thus, the contact resistance reached 12·5 ohms in 13 hours with an eccentricity of 0·10 mm, whereas it took 25 hours to reach this same value with an eccentricity of only 0·03 mm. With high values of eccentricity, such as 0·15-0·20 mm, there is a risk of seizure immediately after starting, even with new contacting elements.

CONCLUSIONS.

The new sliding contacts reduce the parasitic e.m.f. to less than 30 μV under the conditions tested. In temperature measurements with thermocouples, this result corresponds to the maximum errors of 0·4° C up to 600° C, 0·6° C up to 1200° C, and 2·8° C up to 1500° C.

For the indication of rapidly varying temperatures with a cathode-ray oscilloscope, the error due to the sliding contacts is negligible. By using contacting elements connected in parallel, the error is generally low with a galvanometer having a relatively high internal resistance of several hundred ohms. Therefore, temperature measurements by means of thermocouples on parts rotating at high speeds can be made with an accuracy which is adequate for most cases.

The sliding contacts can be used more generally for the measurement of small potential differences of the order of 0·1 mV occurring in a rotating body, provided the variation in p.d. is not too rapid. A systematic study of the effects of vibration will be the subject of a further investigation.

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The "Iron Hand" Unloading Principle

The " Iron Hand " unloading device, manufactured by the Sahlin Engineering Company of Birmingham, U.S.A., is an unusual device. It is used chiefly for removing sheet metal parts automatically from dies and enables presses to be used to a much higher capacity than is possible with manual unloading. It can be used at speeds up to 50 strokes per minute. The device can be provided with a variety of gripping jaws to suit the requirements of the component and can be installed on almost all types of presses, shearing machines, welding machines, as well as on die casting machines. A special model was recently developed for the last mentioned application. Another recent addition to the range is a portable " roll away " model for unloading small punch presses. In this model a straight line reciprocating motion is used, instead of the swinging motion used in the other models. The operation of the device is basically as follows. When the press has completed an operation, a limit switch is

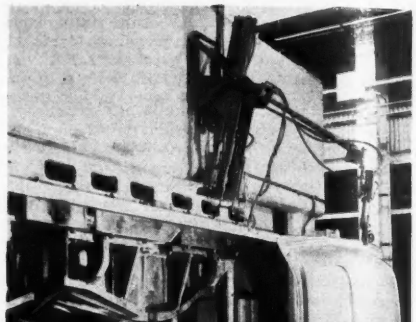

Fig. 1.

actuated, causing the jaw head to advance and grip the part as soon as the ram has risen sufficiently. The jaws, which can lift up to 200 lb, take the part out of the machine, swing it back and place it on a table or conveyor. The jaw head then returns to its starting position and is ready for the next operation. The jaws are fully adjustable and the arm can swing the component as far as eight feet from the die. Adjustment for handling various components can be made in a few minutes. This device not only speeds up operation of presses and other machines, but also ensures safety of operators. It has built-in safety devices to protect operators when it is not in use, for keeping the arm in the " up " position, and a limit switch is incorporated to stop the press midway in its stroke, should the jaw not retract satisfactorily. Among the wide variety of components that are being handled by the " Iron Hand " are motor car body panels, sinks, bath tubs, hot die castings and plastic mouldings. Fig. 1 shows a motor car roof weighing 75 lb being lifted out of a heavy press, and Fig. 2 the small " roll away " model being used for unloading a small high-speed press.

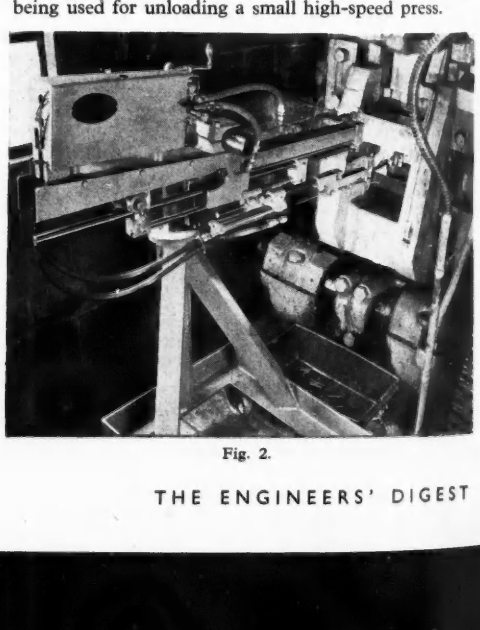

Fig. 2.

Modern Machine Tool Manufacturing Methods

By T. P. N. Burness, M.I.Mech.E., M.I.P.E.*

The machine tool industry is now widely regarded as the keystone of the bridge which supports the whole manufacturing structure of this country. Consequently, it is essential that those who make cheap manufacturing possible should themselves be efficient in the running of their plants and the manufacture of their machines.

It is not so many years ago that the British machine tool industry was regarded as the Cinderella of the engineering trade and was given very little official encouragement; prices for machine tools were so low that the establishment of research departments, which are essential for scientific progress, was confined to relatively few firms.

Today, the machine tool industry stands out as one of the virile sections of the engineering industry, and it has shown conclusively that it has not only the will but also the ability to produce machine tools which are comparable in quality and performance with the best the world can produce.

There are two types of business with which the machine tool maker has to deal; firstly, there is the machine which is supplied as standard, leaving the user to provide the equipment necessary to cater for his particular requirements. This is generally a straightforward type of business which can be readily dealt with by a comparatively simple organisation.

On the other hand, there is a growing tendency for large manufacturing concerns concerned with quantity production to require the machine tool maker to tender for, and supply, special automatic cycle machines with complete tooling equipment for the particular component concerned, at the same time quoting guaranteed production times.

This type of work obviously involves a considerable amount of drawing office and commercial work, which means the retention of an expensive engineering and development staff, which, in turn, creates high overheads. These must be spread over, not only the special machines in question, but standard machines as well, and such factors must be borne in mind by the purchaser of machine tools when weighing up the purchase price of a machine tool.

In considering the cheap production of machine tools, there are four points which must be kept uppermost in our minds, and these are :—

(1) To produce a design which is simple to manufacture, but which will give a first-class performance and, at the same time, be "easy on the eye" as far as appearance is concerned.
(2) To cheapen the cost of production by the extensive use of jigs, tools and fixtures, and so utilise a mixed standard of labour.
(3) To eliminate the human factor as far as possible by precision methods in the machine shop, thus narrowing down the amount of handwork necessary in the fitting and assembling departments. This procedure also reacts to advantage in reducing the time necessary to secure a uniform performance.
(4) Finally, to provide adequate service to any part of the world by being able to supply interchangeable spare parts which can be utilised on the original product with little or no handwork.

To achieve these objectives, the greatest attention should be paid to quality control and interchangeability of parts, without which little success can be achieved in low-cost production without sacrifice of quality and performance.

To establish and maintain these two fundamental principles throughout an organization, it is obvious that management should be efficient at all levels, for without close supervision of labour satisfactory results cannot be readily achieved.

Modern manufacturing methods must obviously be the keynote of cheaper production, and with the general rise in manufacturing costs, particularly overheads, the man-hours on any job must be kept to a minimum.

It is, therefore, essential that before a new model is launched into production there should be a complete investigation of the design by the drawing office and the various departments concerned with manufacture until all are satisfied that the maximum simplicity has been achieved, consistent with the satisfactory performance of the machine.

And now for a few observations on the various departments which have such a vital bearing on the cost of manufacture and design.

Design.

Design plays a very important part in successful manufacturing, particularly as far as interchangeability and high-quality finish are concerned, and thus the manner in which a design is presented by the drawing office to the works is of vital importance. The drawing should be to a very large extent the text book of the job, and information should be clear and concise in order to ease, as far as possible, the task of production. In the past, and even now, there has been too little collaboration between the designing and the producing staffs, and it should be possible to bridge this very real gulf by producing something which will not only work well, but which can be easily manufactured.

Standardisation in the dimensioning of drawings is another important factor, and ambiguous sizes, incorrect datums, incomplete material specifications, and indistinct dimensions should be rigorously eliminated. The class of finish should always be indicated, and it should not be overlooked that lateral limits are equally as important as diametrical limits. General arrangements of group assemblies showing the part numbers and their disposition are equally necessary, and they will well repay the time spent on their production.

Limits on Drawings.

Limits are of vital importance, and fine limits should be set by the production department after the prototype has been built, tried out, and tested thoroughly. The fixing of limits is not a text-book job, but is obviously best done by the combination of present and past experience of production-minded engineers possessing an intimate knowledge of the duty the particular part has to perform.

All limits, however, should eventually be transmitted to the drawing office for incorporation on the drawings, and all alterations should be dealt with in the same fashion. There is nothing more confusing to good order than to find the works following a practice different from that specified on the drawings.

Castings.

Great care and attention should be given to the design of castings. Most jobs are made up of a large percentage of cast iron and the problem presented to the foundry should be as simple as possible; wherever practicable, parts should be specifically designed for machine moulding.

The importance of accurate and sound castings cannot be over-emphasised. It must be realised that interchangeability of parts necessitates a fully tooled job, and so castings must go into their respective fixtures without difficulty, and location spots must be accurate and reliable.

Coring must be correctly positioned and wall

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thicknesses should be reasonably accurate. The positioning of cores is often a bugbear in the foundry and the only way to overcome the trouble is by the extensive use of simple jigs and fixtures for producing and setting interchangeable cores.

It should not be necessary to mark out any but the largest-size castings, as it is a comparatively simple method to provide proving templates and so enable contours and core positions of castings to be determined at a glance. Sound metal is imperative for any kind of casting, particularly when the question of interchangeability arises, as all kinds of machining errors can crop up through the problem of spongy metal, to say nothing of the effect on performance when rubbing parts are affected.

Metallurgical Department.

Many engineering organisations operate an iron foundry in conjunction with the engineering side of the works, and when this is so, a fully staffed and well equipped laboratory is almost a necessary adjunct.

Metallurgical control in an iron foundry is an essential part of its working ; not only that, but the metallurgical service available in such a department can be readily extended to cover the whole of the engineering side as well, as modern conditions demand a considerable amount of material testing, in addition to the various heat treatment processes which have come to be an integral part of high-class engineering products.

Investigation of breakages is another useful sphere for metallurgical services, and the harnessing of science to practical knowledge becomes more and more necessary in these days of rapid progress.

Planning, Rate-Fixing, Jig and Tool Department.

The efficient planning of a job for manufacture is without doubt a most important link in any organisation, for it is in this department that the job can be made or marred. The personnel should include men who have had extensive experience of machining and fitting, so that they can formulate in their minds the correct procedure to be adopted by the shops.

Adequate machining times must be allowed if the split thousandth is to rank of greater importance than the split second, and although it is desirable that these two ideals should run together, the Author is always prepared to attach more importance to the split thousandth than the split second when considering manufacturing costs, to say nothing of interchangeability and quality.

Datum machining points must be carefully considered to ensure that parts which require a multitude of operations are machined as far as possible from one master location, so that errors which creep into manufacture do not become cumulative.

The planning department must indicate on the planning sheet where jigs, fixtures and tools are necessary, so that the tool drawing office can segregate these operations and design and supply the necessary equipment for the general scheme. The design of jigs, tools and fixtures should be kept as far as possible on the simplest lines, with due regard to efficiency.

There is a tendency amongst tool draughtsmen to over-elaborate and design fancy fixtures and tools which have nothing to commend them over their plainer and less expensive brethren, but which too often have the awkward result of complicating manufacture rather than simplifying it. Try-out engineers should be attached to this department to ensure that before fixtures and tooling are launched into the production shops, they have been carefully checked and are producing articles to the pre-determined sizes.

Maintenance of jigs, tools and fixtures is also an essential point, and a periodical survey in conjunction with the inspection department is a necessary procedure if interchangeability and quality of components are to be maintained.

Inspection Department.

There are many people who regard inspection as merely an additional burden on overheads, but if interchangeability and quality control are to be exercised, it is essential to have 100 per cent inspection. The department should be entirely independent of the general works organisation, as members of the staff have to exercise an unbiased mind in the execution of their duties. A properly organised inspection department can assist tremendously in making possible the production of accurately machined interchangeable parts, which reduces the job in the fitting and erecting shops from expensive fitting and rectification operations to a mere matter of assembly.

It should be borne in mind, however, that the work of an inspection department is supplementary to that of the supervisory staff and in no way relieves the works executives from responsibility for defective work. Its job is to bring defective work to the attention of the supervisory staff in order that it does not become a recurrent factor, and above all the inspection department must be exonerated from the invidious position of being held responsible for bad workmanship.

General Machine Shop Practice.

The machine shop is the battleground of modern production, and it is up to that department to produce interchangeable components of the requisite quality and as far as possible reduce the job of fitting and erection to one of sub and final assembly.

Most modern machine tools with any pretensions to quality, provided they are properly tooled and manned, will produce work to an accuracy of at least 0·0005 in., and as this limit covers all but the highest form of precision work I will confine my remarks meanwhile to work within that particular range.

Before attempting to produce any article in quantity it is essential to make a prototype. When the design and manufacturing departments are satisfied that the performance of the particular article is up to the desired standard, then is the time for the manufacturing limits to be fixed by those competent members of the organisation whose experience fits them for the job.

Manufacturing is largely a question of properly dimensioned castings which provide the support for a suitable disposition of gears, shafts or other interlinking mechanical components.

The sizing of bores, such as are to be found in the larger type of castings, can be readily dealt with by the use of properly designed boring bars working in fixtures with hardened bush bearings and equipped with suitable diametrical and facing cutters.

The boring bars should be fitted with suitable stops so that the facing of bosses can be done to definite size. Properly applied, such equipment will control shaft bore, spacing of facings, and pitch centres of shafts, and it must be remembered that unless these particular items are correct, it is little use making accurate components to put inside them.

Bore fits are generally classified under three headings, driving, close and running fits, but whichever kind of fit is required the sizing must conform to that determined on the prototype, plus a maximum error of 0·0005 in. Similarly, in the case of the corresponding shaft, the size must be determined by the prototype minus a maximum error of 0·0005 in.

In the case of easily handled components, like gears, bores of small size can be readily and accurately reproduced on an automatic sizing internal grinder well within the prescribed limit, while pins and smaller shafts can either be sized on plain external grinding machines or, where quantities and design permit, by passing through a centreless grinder to a similar degree of accuracy.

Wherever possible, parts such as gears should have their bosses faced by grinding at the same time as the

bore, then finally sized to thickness on a rotary surface grinder or similar machine.

Whenever a bore or a shaft is dealt with, in the case of an easily transportable part, a standard mating part should always be available to check interchangeability, for although a shaft which is only 0·0001 in. above size might be classified as highly accurate, it is not interchangeable if it will not enter the appropriate bore.

DISTORTION OF PARTS.

One hears a good deal about trouble being experienced due to the distortion which takes place at various stages of machining, particularly with regard to large castings.

There are many people still under the mistaken impression that the weathering of castings in the open is a cure for distortion, but closer investigation has proved that this is not so.

The ideal way to deal with potential distortion in castings is, of course, to normalise by heat treatment after rough machining, but this is an insuperable problem to most firms who do not have furnaces large enough to accommodate such a practice.

Accurate planing is the basic factor in the machining of large castings, as the planed surface is generally used to locate further operations such as boring and drilling.

All large castings, when the outer skin is broken, are subject to distortion, and, therefore, it follows that to maintain accuracy the introduction of separate roughing and finishing operations is highly desirable. The casting should be unclamped between operations to allow the natural twist in the casting to take place.

These extra operations, though a little more expensive, are always well worth-while and must be included if accuracy is to be maintained.

(*Continued from page* 306)

SWEDEN

Foam and Foaming Liquids

By V. ÖHMAN. (From *Teknisk Tidskrift*, Vol. 82, No. 14, April 8, 1952, pp. 317-322, 10 illustrations.)

It is generally recognised that foam has now taken a prominent position in technical development. It is used, for instance, for fire fighting, flotation processes, and washing, besides having important applications in beverages and foodstuffs. At present, foam is also being employed in the plastics industry for the production of porous materials with a foam-like structure.

CHARACTERISTICS OF FOAM AND FOAM FORMATION

FOAM is not merely any emulsion of gas and water. It is a system of gas bubbles which are separated from each other by extremely thin liquid membranes or films. The gas bubbles are of a fairly uniform size without being absolutely identical, and form a very fine structure. There are only a few geometric figures without interspace which the bubbles can assume; frequently these are rhombo-dodecahedrons tending to have a nearly spherical shape owing to surface tension. When water is used as a foaming fluid, it must include substances which have an influence on surface tensions, which are either raised or lowered, in order to produce foam.

A clear theoretical basis in regard to foam formation was set forth by Bartsch in 1924. He confirmed Edser's finding that foam formation primarily depends on the formation of a surface layer (i.e., a Gibbs' layer), which differs considerably in its composition from the remainder of the solution. Bartsch also pointed out that increased foaming tendency is obtained with highly heterogeneous layers, a result which has been confirmed by recent work.

Surface tension is related to concentration by means of Szyszkowski's empirical formula :

$$(\gamma_M - \gamma_L)/\gamma_M = b \log_e [(C/K) + 1]$$

where C = concentration, γ_M = surface tension of solute, γ_L = surface tension of solution, while b and K are constants.

The reciprocal of K is a measure of the capillary activity of the active substance. Bartsch pointed out that in assessing the influence of capillarity on foam formation, the solubility of the surface-active agent must be taken into account, since an increase in its solubility improves the foaming ability of the system. He frequently found it convenient, therefore, to use the "relative capillary activity," which is obtained by multiplying the capillary activity (calculated by means of the corresponding formulae) by the solubility in moles per litre.

Bartsch determined the foaminess curves of a number of alcohols and fatty acids as a function of the degree of saturation. The curves rise steeply at first and reach their maximum values at relative saturations between 10 and 20 per cent, after which they fall off to zero at 100 per cent saturation. Comparing these results with the curve for surface tension variation for fatty acid solutions, Bartsch found that the surface tension curve decreases hyperbolically with increasing values of saturation and that its variation is inversely proportional to that of the foaminess curves for saturations below 20 per cent. This supports his view that foaminess is related to the heterogeneity of the surface layer. Further investigations served to determine the threshold value for foam formation as a function of the concentration. In opposition to the assertions of Ostwald and Steiner, who considered it was an error to relate the decrease in surface tension to foaming ability, Bartsch pointed out that it is possible to find cases where the heterogeneous nature of the surface layer cannot be revealed by surface tension measurements, and that foam formation and foam stability are not comparable quantities.

PERSISTENCY OF FOAMS

The stability of lyophobic foams is based on electrical charges. Foams of this type can be destroyed or "coagulated" by contact with positive ions. In contrast, lyophilic foams are practically insensitive to electrolytes. It should be noted in this connection that the liquid layer of a lyophilic foam may well contain colloids of lyophobic character.

In his investigations of lyophobic foams, Bartsch determined the "electrolyte threshold," that is, the quantity of electrolyte, in millimoles per litre, which would be required to destroy systems with various degrees of stability. Furthermore, the electrolyte threshold for an isoamylalcohol foam and the coagulation value for an arsenic trisulphide sol were determined in comparative tests with various electrolytes (NaCl, $BaCl_2$ and $AlCl_3$ for the foam, and KCl and $CaCl_2$ for the sol). The electrolyte concentrations required to produce identical degrees of coagulation were determined and it was found that both the threshold effect and the coagulation effect rise extremely rapidly with valency. It is thus justified to regard the reduction

of stability of foam as a phenomenon corresponding to the coagulation of a sol.

In the same way as coagulation in a sol can be opposed by peptisers, it is possible to increase the stability of a lyophobic foam by the addition of negative ions. Hydroxyl ions have been found to have a strong stabilising effect, and carbonations and citrations are also effective.

Another way of improving the stability of lyophobic foam is by raising the surface viscosity of the solution. However, the stabilising additive must be such that the foam-forming substance will not penetrate through it from the surface layer. Thus, little increase in stability is obtained for isoamylalcohol solutions by adding glycol or glycerol. Furthermore, the stabilising agent must be sufficiently surface-active, so that a small quantity will be able to produce the required effect. For instance, the stability value of isoamylalcohol solutions can be doubled by adding about 0·00001 per cent of soap, whereas some 0·001 per cent of gelatine would be required to obtain the same effect.

The lyophilic foams also have a heterogeneous surface layer with one or several surface-active substances. However, these substances are colloids of such a molecular size that the surface layer will have a high viscosity. In some cases, the gel character of the liquid films is clearly evident. The colloidal agents do not always assist each other; one substance may expel another from the active layer, thus impairing film stability.

Extensive investigations of lyophilic foams have been carried out by Clark and his co-workers, particularly in connection with the hydrolysis products of blood, keratin, and glue.

TEST PROCEDURES

Laboratory tests form only a very limited part of the investigations which are carried out on foams and foaming fluids. Bulk tests, for instance in fire fighting, are required to complete the laboratory results for a correct assessment of the technical and economic value of a foaming fluid.

Viscosity: The surface viscosity of liquids is generally determined by means of a disc suspended on a torsion wire. In Clark's arrangement, the vessel with the solution is placed on a plate which is rotated at a speed of 2·3 rpm by a driving linkage. By operating a screw, the vessel is raised until the glass or aluminium disc is immersed at the appropriate distance below the surface of the fluid. Owing to viscous shear, the disc tends to rotate with the fluid, and its angular deflection is indicated by a pointer. The test is repeated with successively reduced distances between the disc upper surface and the surface of the liquid, in order to measure the increase in viscosity until surface rupture occurs.

The mechanical strength of foam can also be determined by viscometer tests. Clark's apparatus for this purpose comprises a copper plate which is suspended from a torsion wire and immersed in a vessel containing the foam. The vessel is rotated at 8 rpm.

Among other methods for determining the viscosity of foam, the method evolved by Grove and his co-workers should be mentioned. In this test, the foam flows at a certain velocity through a tube in which there is a rod suspended on a spiral spring. The rod deflection is used as an indication, and the viscometer is calibrated with a sugar solution.

A kinetic foam viscometer which has been used at Sandvik for the past eighteen months consists of a horizontally-arranged "Comet B.B." spraying tube connected to a differential manometer. A blow-off device is incorporated between the measuring positions in some applications. The pressure drop is used as a measure of foam viscosity. By determining also the pressure drop in the vicinity of the intake, the rate of foam formation can be studied. With this system, the viscosity of the foam is determined under conditions of heavy compression. To avoid compression effects, the apparatus has recently been modified by the addition of an auxiliary tube at the end of the B.B. tube and the differential manometer is mounted on this auxiliary tube. In this manner, the measuring sensitivity is increased considerably.

Foam coefficient and air volume factor: Under laboratory conditions, the foam-forming ability of a liquid is generally determined by shaking the solution by hand in a graduated vessel. Another more recent method is to stir up the solution in a cylinder by means of a perforated plate. Both methods serve to determine the "foam coefficient," i.e., the ratio of the volume of foam produced to the initial volume of the liquid. Alternatively, the air volume factor, which is the ratio of

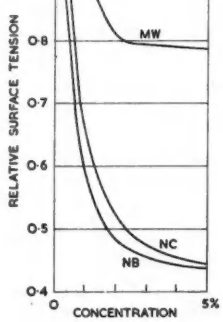

Fig. 1. **Surface tension at different concentrations.**
MW = hydrolysis product of blood
NC = soap
NB = mixture of glue and wetting agent.

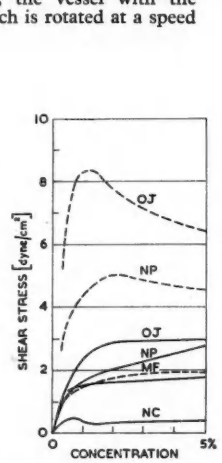

Fig. 2. **Surface viscosity in benzine (dotted lines) and air (solid lines) of various hydrolysis products.**
OJ = keratin
NP = blood
MF = blood without iron salts
NC = soap.

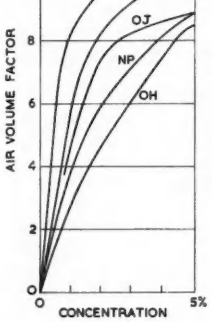

Fig. 3. **Air volume factor of various hydrolysis products.**
OJ = keratin
NP = blood
OH = soy-protein
NC = soap
NB = mixture of glue and wetting agent

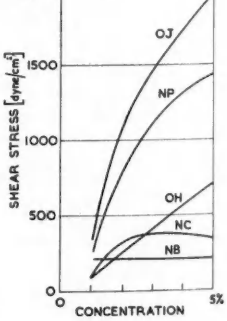

Fig. 4. **Foam viscosity of various hydrolysis products.**
(Same symbols as in Fig. 3).

the quantity of air used per quantity of liquid, is determined. Both ratios are functions of bubble size and of the purity of the foam, i.e., its freedom from liquid droplets.

Clark's apparatus comprises a plate of 5 cm diameter, perforated with 86 holes of 0·3 mm diameter. The plate is moved up and down in a glass tube 42·6 cm high at a rate of 240 strokes per minute. Generally, 50 millilitres of liquid are used and the mixing time is 30 sec. After the test, the foam is transferred into a measuring cylinder of 1 litre capacity and the used mixture of foaming fluid and water is added in the cylinder until the foam level rises up to the one-litre marking. The difference between 1 litre and the volume of liquid added is the air content of the foam.

Thermal stability: The viscosity of a foam is a measure of its mechanical strength. For fire fighting, however, the foam should also have heat-resisting properties. The thermal behaviour of a foaming liquid can be tested according to Amsel's method, by placing it under an electrical heating element in a furnace and measuring the time it takes to sink down through a certain distance, for instance, from 350 to 200 millilitres.

FOAM-FORMING ABILITY AND STABILITY

The colloidal foaming agents used by Clark were surface-active substances. Compared with soap (Fig. 1), the hydrolysis product of blood gives a small reduction in surface tension. The surface-active properties of Clark's glue solutions were not so much due to the glue as to the mixture used as a wetting agent, viz., ammonium salt and sulpho-isopropyl naphthalene. When surface viscosity is plotted as a function of concentration (Fig. 2), it is found that the soap curve comes below those for albumin. The addition of iron salts to a solution of hydrolysis products of blood raises the surface viscosity of the solution.

Although it has been stated that the correlation of foam-forming capacity with reduced surface tension is to be considered with caution, the results appear valid to some extent even for lyophilic foams. For instance, from Figs. 1 and 2, it may be concluded that the soap solution will give a high air volume factor owing to a considerable drop in surface tension, but its foam will have a low mechanical strength on account of its low surface viscosity.

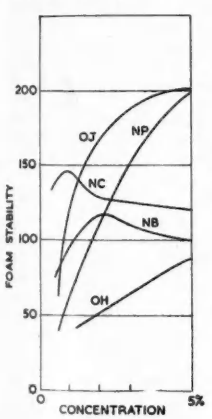

Fig. 5. **Thermal stability at different concentrations.** (Same symbols as in Fig. 3).

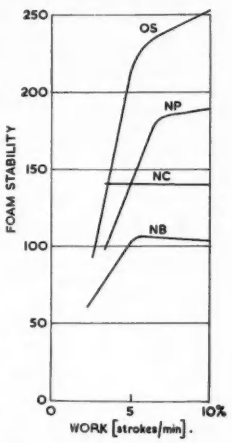

Fig. 6. **Thermal stability at different working energies.**
OS = hydrolysis product of keratin
NP = hydrolysis product of blood
NC = soap
NB = glue with wetting agent

The curves for air volume factor against concentration (Fig. 3) confirm the first of these conclusions. The highest curves are those for glue-wetting agent solutions and soap, which both show marked decreases in surface tension. The tests were carried out with a Clark type foam producer, and similar results were obtained with a Comet tube. The statement on the low mechanical strength of soap is confirmed again by the relation between foam viscosity and concentration, shown in Fig. 4. In this figure, the curves for the glue-wetting agent solution and soap are in the lower part of the diagram. Furthermore, the heat-resisting properties are also dependent on the mechanical strength (see Fig. 5).

In the above tests, the subject of foam formation has been investigated from the point of view of the physical properties, but the chemical aspects of foaming systems must also be taken into account. In Clark's test of blood albumin, an increase in surface viscosity was obtained with the addition of iron salts. Particularly effective was the addition of ferro-sulphate to the hydrolysis products of protein, already previously applied by Sthamer.*

In the foregoing it was stated that fire-fighting foam is of lyophilic character. The colloidal sols, however, contain a negatively charged lyophobic colloid, which is stabilised by a protective colloid. The lyophobic colloid has an extremely complicated structure, and consists mainly of basic salts, bivalent iron and amino acids. A lyophobic sol of this type coagulates if positive ions neutralise the negative charges and this effect increases rapidly with increasing valency.

The iron colloids mixed with air and water go through the following processes. Dilution with water results in the liberation of ferro-ions. In mixing with air, the ferro-ions oxidise to ferri-ions, neutralising the negative charges which are essential for the existence of sols. The iron colloid begins to coagulate, and this results in the formation of viscous substances. This process occurs, of course, with maximum intensity in contact with air, that is, on the surface of the wetting liquid, the viscosity of which increases. This contributes to the stability of the foam.

Foaming liquids should therefore be regarded as a colloidal redox system in which chemical and physical forces co-operate to an extremely high degree to form a stable foam.

*British Patent No. 476,552.

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RUSSIA

An Analysis of Feed Mechanisms in Machine Tools Regarding Uniformity of Advance and Sensitivity of Adjustment

By M. E. ELYASBERG. (From *Stanki i Instrument*, No. 11, 1951 and No. 12, 1951, pp. 1-7 and 6-9, respectively, 16 illustrations.)

From the experimental data presented and the theory derived therefrom it follows that, in the presence of friction between lubricated surfaces at small velocities, transient phenomena are observed which cause the friction force to differ from that in fully established motion. In fully established motion the friction force depends upon the velocity, whilst in the transient phase it is a function of acceleration, velocity and time. At certain combinations of mechanical parameters intermittent motion takes place, physically explained by the initial impulse, which arises from the sudden drop of the friction force in the transition from rest to motion. To eliminate stoppages it is necessary to increase the stiffness of the transmission, or the velocity of advance. The conditions for the dying-out of oscillations and continuous motion depend on the internal friction in the material of the transmission, as well as on other quantities. The theory discussed in this article leads to a method of calculation applicable at the design stage of machine tools.

INTRODUCTION

THIS analysis of feed mechanisms regarding uniformity of motion attempts to establish the conditions necessary to ensure uninterrupted motion at small velocities. The feed velocities of tool supports in machine tools are among the smallest known in mechanical engineering, and have not hitherto received much scientific attention. It is known, however, that under certain conditions an intermittent motion is observed. On engaging the transmission, its elements suffer elastic deformation until the forces transmitted exceed the frictional resistance of the tool support under static friction, whereupon the support starts moving. Owing to the drop in the friction force, the support receives a high acceleration and quickly absorbs the energy stored in the deformed transmission. The support overshoots owing to its intertia. At he end of the "jump" the transmission mechanism is wound up in the opposite sense, and before further motion can take place this deformation must be unwound which causes a period of standstill for the support. The physical sequence described falls into the category generally known as "relaxation oscillations."

The jumps in motion can be of such magnitude that an accurate adjustment of the tool support may become impossible. In order to keep the dimensions of the transmission within reasonable limits, intermittent motion must sometimes be allowed at the lowest feeds. If so, it is nevertheless imperative to ensure a small length of jump.

Relaxation oscillations have been investigated by physicists in the last twenty years, but insufficient experimental data prevented the solution of practical problems in machine tool transmissions. The author's work since 1934 has resulted in methods which are suitable for designers.

I. EXPERIMENTAL DATA.

The experimental investigation of motion under laboratory conditions was carried out on a special rig, Fig. 1. A driven slide, (carriage or support) A, is pushed by a driving slide, E, through a transmission link, in the shape of a beam, C, of calibrated stiffness. Slide A carries pick-ups which produce oscillographic records of displacement, velocity, and acceleration. The data obtained with this equipment have been used to determine the variation of friction force, y, from the equation $m\ddot{x} - y + P = 0$, in which P is the external force, m is the mass of the slide A, and $\ddot{x}$ is its acceleration. All experiments were carried out under conditions of boundary lubrication at small velocities, in which it is possible to neglect the forces of viscous friction. Most of the observations were made with cast-iron slides on cast-iron guides, lubricated with machine oil.

The records of motion and force show the expected oscillatory character of the motion. In some conditions the initial transient vibration is damped out, and an advance with the uniform velocity, v_f, establishes itself. Other conditions cause the oscillatory motion to be periodically interrupted.

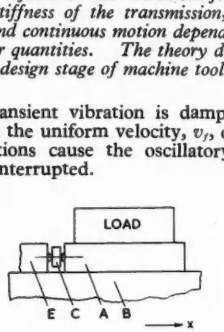


Fig. 1

An increase in the stiffness of the transmission and in the velocity, v_f, helps to transform intermittent into continuous motion. Thus, other things being equal, a given stiffness c of the transmission determines a critical speed v_f^*, and vice versa, at a speed v_f, below the critical v_f^*, uniform motion is impossible.

Fig. 4 reproduces portions from oscillographic records taken with increasing values of v_f. At first we observe motion with intermittent stops, shown by the flat tops and bottoms of the waves. At a velocity of $v_f = 2{\cdot}5$ mm/sec the stops cease. Further increases in the velocity v_f proceed as a continuous oscillatory motion with increasing damping.

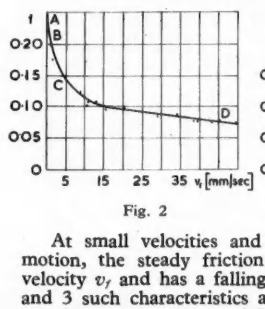


Fig. 2

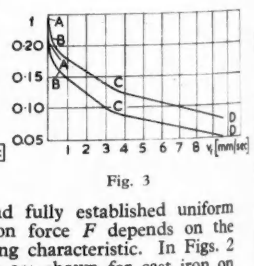


Fig. 3

At small velocities and fully established uniform motion, the steady friction force F depends on the velocity v_f and has a falling characteristic. In Figs. 2 and 3 such characteristics are shown for cast iron on cast iron at a pressure of 2·3 kg/mm². These graphs have a steeply falling range AB, within which the static friction force suddenly drops, as soon as sliding begins. Over the range BC, the force F depends on

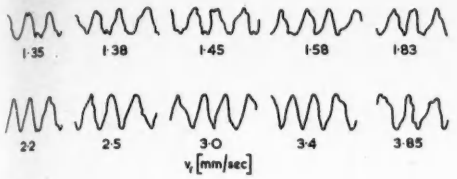


Fig. 4

velocity in a roughly linear relation. Further on, the dependence of the friction on speed becomes less pronounced. In Fig. 8 this relationship is transformed into a simplified linear diagram.

Under the conditions of transient oscillatory motion the friction force also varies, but the variation obeys a law different from the above. Experiment shows that the transient friction force y is out of phase with the velocity $\dot{x}$, and is almost in phase with the acceleration $\ddot{x}$.

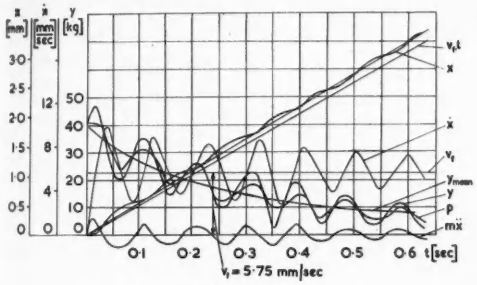


Fig. 5

Fig. 5, which is a redrawn oscillographic record, shows the dependence of the friction force on acceleration. Fig. 6, reconstructed from Fig. 5, shows the relatively weak dependence of the friction force on velocity, observed in transient motion, but also the change of friction force from one cycle to another. The friction force falls gradually with the attenuation of transient vibrations to its value at the established uniform velocity.

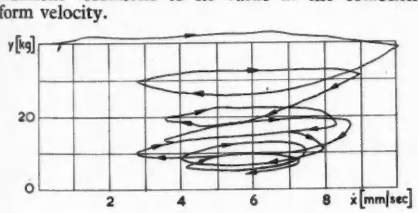


Fig. 6

Special experiments in which the velocity was made to approach the steady state very quickly have shown that the friction force lagged behind the velocity, and then slowly reached the value corresponding to $\dot{x}$. In Fig. 7a and b, the variation of the friction force in relation to velocity and time is shown. It is seen that in regions where velocity is almost steady, the friction force continues to change.

The measured frequency of oscillation is invariably much lower than the natural frequency of harmonic oscillations determined by the mass of the slide and the stiffness of the transmission.

The oscillations in interrupted motion are non-symmetrical. The peaks of $\dot{x}$ and $\ddot{x}$ are larger than the troughs, measured about v_f and zero acceleration respectively.

After a prolonged period of standstill, the first jump in intermittent motion is larger than the following.

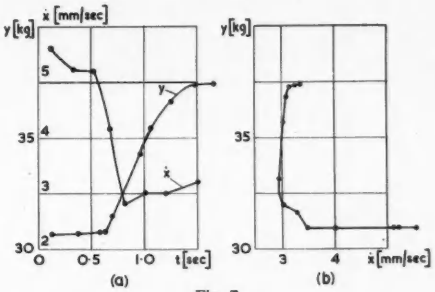


Fig. 7

This phenomenon is not observed after short standstill periods.

II. Basic Assumptions.

It has been shown above that at the beginning of motion the friction force drops suddenly. The assumption is made that this jump is instantaneous. AB in

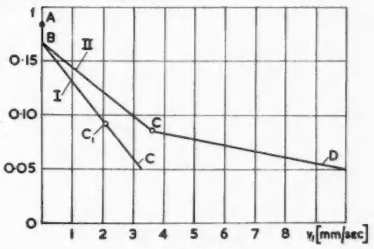


Fig. 8

Fig. 8 shows the assumed drop from the static friction coefficient f_{01} to the initial coefficient of dynamic friction f_0. Further on, the coefficient of friction is assumed to vary linearly:

$$f = f_0 + \beta v_f \quad .. \quad .. \quad .. \quad (1a)$$

Multiplying this relation by the normal force N we obtain

$$F = F_0 + b v_f \quad .. \quad .. \quad .. \quad (1)$$

The drop from the static to the initial dynamic friction can be represented by a fraction δ of the static friction coefficient.

$$f_{01} - f_0 = \delta f_{01} \quad .. \quad .. \quad .. \quad (2)$$

Considering the motion of slide A (Fig. 1), let c be the stiffness of the elastic element C, and l be the displacement of the point of application of force P, due to the deformation of elastic link C before the slide begins to move. v_f is the uniform velocity of this point, x is the displacement of the slide, and t is time. Then the total displacement of the elastic element in the beginning of movement of the slide is $l_0 - x + v_f t$. The force associated with this displacement, owing to the elasticity of the link C, is balanced by the internal friction y_p in the transmitting link C, the external friction y, and the inertia force $m\ddot{x}$. Hence:

$$c(l_0 - x + v_f t) - y_p - y - m\ddot{x} = 0 \quad .. \quad (3')$$

We now express the external friction y by the sum of constant term F, a velocity term y_1, and an acceleration term $y_2 = b_2 \ddot{x}$. The velocity term, as we have seen, must take transient conditions into account. Experiments described above show that we may assume the rate of change of the velocity-dependent friction force to be proportional to the difference between the actual velocity $\dot{x}$ of the slide, and the velocity v_y, which would correspond to a friction force y in steady motion thus:

$$\dot{y}_1 = -\,b_1\,(\dot{x} - v_v)$$

However, in steady motion the friction force has only a constant and a velocity term, eq. (1), and we therefore obtain the following expression for the velocity term:

$$y_1 = (b_1/b)\int_0^t [y - (F_0 + b\,\dot{x})]\,dt$$

from which the complete expression for the friction force can be derived as

$$y = b_2\,\ddot{x} + (b_1/b)\int_0^t [y - (F_0 + b\,\dot{x})]\,dt + F_0 \quad (4')$$

The author has found a basis for eq. (4) in the molecular theory of friction.

It will be shown that the internal friction of the transmission link introduced in eq. (3′) is by no means unimportant. The assumption that internal friction is proportional to the velocity of deformation is mathematically simple, but does not adequately represent metallic materials.

Experiments show that the forces of internal friction depend on the amplitude of stresses. The stress amplitude determines the size of the hysteresis loop in stress reversals, which measures the dissipation of energy. Exact theory leads to non-linear equations, but an adequate simplification is obtained from an assumption that the internal friction force is proportional to the velocity of deformation and inversely proportional to the frequency. This assumption ensures that the friction force for one cycle is independent of the velocity of deformation, but at the same time the linearity of the equations is preseved. The friction force y_p is assumed to be proportional to the velocity of deformation ξ_m, but the coefficient of proportionality b_p is not a constant of the material, but is expressed by the relation:

$$b_p = 2\,\beta_p\,c/(\pi\,\omega)$$

where β_p is a material constant, ω is the frequency of the oscillation, and $c\,\xi_m$ expresses the amplitude of the stress in the link. For analytical purposes

$$y_p = b_p\,(\dot{x} - v_f)$$

III. Solution of Equations.

From eqs. (3′) and (4′) we obtain a system of linear differential equations of the third order:

$$\dddot{x} + \frac{b_p}{m}\ddot{x} + k^2\,\dot{x} + \frac{\dot{y}}{m} = k^2\,v_f + \frac{F_{02}}{m} \quad .. \quad (3)$$

$$b_2\,\dddot{x} - b_1\,\dot{x} - \dot{y} + y\,b_1/b = F_0\,b_1/b \quad .. \quad (4)$$

where $F_{02} = c\,l_0 + b_p\,v_f = F_0 + \delta\,F_{01} + b_p\,v_f$ and $k^2 = c/m$.

In steady motion, that is, after the oscillations have died out, the friction force, in accordance with eq. (1), falls to a value given by the following expression

$$y = F_0 + b\,v_f \quad .. \quad .. \quad (5)$$

and the internal friction force vanishes.

Clearly, the fall in the external and internal friction forces will cause a drop in the deformation of the elastic link compared with the deformation at the moment of starting expressed by the displacement $[\delta\,F_{01} - (b + b_p)\,v_f]/c$. Consequently, in steady motion

$$x = v_f\,t + [\delta\,F_{01} - (b + b_p)\,v_f]/c \quad .. \quad (6)$$

Eqs. (5) and (6) describe the steady motion and it can be shown easily that they are particular solutions of the non-homogeneous eqs. (3) and (4).

The particular solutions of the homogeneous equations consist of the substitutions

$$\bar{x} = A\,e^{\lambda t} \quad .. \quad .. \quad .. \quad (7)$$

$$\bar{y} = B\,e^{\lambda t} \quad .. \quad .. \quad .. \quad (8)$$

The general solutions of eqs. (3) and (4) are expressed, as usual, by the sum of the particular solutions of the homogeneous and the non-homogeneous systems:

$$x = \frac{C_1}{m}\,e^{\alpha t} + (C_2\cos\omega t + C_3\sin\omega t)\,\frac{e^{rt}}{m} + v_f\,t + \frac{\delta\,F_{01} - (b + b_p)\,v_f}{c} \quad .. \quad .. \quad (9)$$

$$y = C_1\left(\alpha^2 + \frac{b_p}{m}\,\alpha + k^2\right)e^{\alpha t} - \left\{\left[C_2\left(r^2 + \frac{b_p\,r}{m} + k^2 - \omega^2\right) + C_3\,\omega\left(2\,r + \frac{b_p}{m}\right)\right]\cos\omega t + \left[C_3\left(r^2 + \frac{b_p\,r}{m} + k^2 - \omega^2\right) - C_2\,\omega\left(2\,r + \frac{b_p}{m}\right)\right]\sin\omega t\right\}e^{rt} + F_0 + b\,v_f \quad .. \quad .. \quad (10)$$

$$\dot{x} = \frac{C_1}{m}\,\alpha\,e^{\alpha t} + [(C_2\,r + C_3\,\omega)\cos\omega t + (C_3 r - C_2\omega)\sin\omega t]\,\frac{e^{rt}}{m} + v_f \quad .. \quad (11)$$

At $t = 0$ the initial conditions are

$$x_0 = 0\ ;\ \dot{x}_0 = 0\ ;\ y_0 = F_0$$

Introducing these values of the variables into eqs. (9) (10) and (11), a set of equations is obtained which yields the constants of integration, C_1, C_2, and C_3.

IV. Roots of Characteristic Equation.

The characteristic equation derived from the homogeneous system upon introduction of the substitutions (7) and (8) is cubic:

$$\lambda^3 + \frac{b_p - b_1\,m/b}{m_1}\,\lambda^2 + \frac{c - b_1\,b_p/b - b_1}{m_1}\,\lambda - \frac{b_1}{b}\,k_1 = 0 \quad (12)$$

where $m_1 = m + b_2$ and $k_1^2 = c/(m + b_2)$

This cubic equation has roots which can be expressed in the following form:

$$\lambda_1 = \alpha\ ;\ \lambda_2 = r + i\,\omega\ ;\ \lambda_3 = r - i\,\omega$$

These roots are most conveniently obtained by means of an iteration method. In the actual systems described by these equations the value of k_1^2 is large compared with the two first terms of the equation, which can therefore be neglected. Experience shows that this approximation gives the root λ_1 with an accuracy to a small fraction of 1 per cent, and can therefore be adopted in practice. This approximation enables us to write down root λ_1 in explicit form:

$$\alpha \approx \alpha_1 = \frac{1}{b/b_1 - (b_p + b)/c} \quad .. \quad (13)$$

The well-known relations between the roots of a cubic quickly render solutions for the remaining roots:

$$r = \tfrac{1}{2}\,(-\,b_p/m_1 + b_1\,m/(b\,m_1) - \alpha) \quad .. \quad (14)$$

$$\omega = \sqrt{k_1^2\,b_1/(b\,\alpha) - r^2} \quad .. \quad .. \quad (15)$$

(To be continued)

Special Purpose Machine Tools and the Unit Construction Principle

By J. C. Z. Martin, D.L.C.(Hons.), Grad.I.Prod.E.

One of the most important developments in the machine tool field during and since World War II has been the increasing use of special purpose machine tools, and as a logical next step, the utilisation of standardised units for constructing these special purpose machine tools.

Special Purpose Machine Tools.

Special purpose machine tools as such are not new to the production engineer. They were highly developed in the U.S.A. during the last two decades and applied with spectacular success in large-volume industries for the production of motor car and aircraft components, internal combustion engines, electric motors, domestic appliances and other mass-produced articles. The large domestic market for these articles in the U.S.A. has amply justified the relatively high capital investment required. The economies brought about by the use of these machines on long production runs proved them to be a sound investment. These economies include not only the direct ones, i.e., lower floor-to-floor times for a given operation, but also those reflected indirectly in a smooth production flow, efficient utilization of factory floor area, reduced labour requirements and the possibility of substituting lower-grade labour than that required for operating normal universal machine tools. On reflection, the reasons for the various advantages of special purpose machines are quite self-evident.

A special purpose machine tool is a much more functional solution of a machining problem than the adaptation of a universal machine tool. The latter has to cater for a wide variety of requirements and many of its features are not utilized in any one given machining operation. For all practical purposes these features are then superfluous for that particular operation and are sometimes even detrimental, in that they may hamper most efficient machining. Furthermore, electrical power may be utilized for driving superfluous gearing and for overcoming friction in bearings and mechanisms, which do not contribute in any way to the operation in hand. The skill required normally for operating a universal machine tool is often unnecessary for special purpose machine tools because of their simpler, functional design. The number of levers, handwheels and other controls is normally relatively small, as they are only required for a strictly limited number of functions and variables. Special purpose machines are often semi- or fully automatic and utilize mechanical, hydraulic or electrical control systems. In fact, recent developments in the field of automatic controls are being applied to special purpose machines, making them even less dependent on the human element. The operator's work consists mainly of loading and unloading components and the machines, once correctly set up, are almost foolproof. The skill is thus virtually built into the machine during the design stage.

The general technical superiority of special purpose machine tools is well established and the only reason for the apparent reluctance of part of the British and Continental industry to utilize them to a greater extent has been, and still is, the initial cost of these machines, viewed against the background of relatively short production runs. A calculated economic comparison, shown in Table I, analyses the various factors involved and indicates the savings that can be achieved by substituting special purpose for universal machine tools. The figures, which should not be regarded as absolute as they are intended only for comparison purposes and do not allow for depreciation, refer to the machining of internal combustion engine cylinder blocks by four different methods. The first method uses normal, universal machine tools, equipped with simple fixtures. The second method employs a number of special purpose machines, and the third method is an improved development of the second, based on further experience. The fourth method uses a highly developed special purpose six-station vertical machine. This machine was not actually used in practice and the data in the table are taken from design specifications and estimates. It is assumed that the various installations can be utilised to the full, and clearly the cost per component will be affected by the total number of components produced. The relationship between cost per component and the yearly output for methods three and four is illustrated in Fig. 1. The intersection of the two curves shows that at a yearly output of

Table I. Economic comparison of four different methods of machining a component.

Method	1	2	3	4
Production time per component (mins.)	2370	660	432	110
Overall cost per component (£)	13	5·15	4·63	3·05
Labour cost per component (£)	3·68	1·02	0·67	0·18
Basic cost per component (£)	9·32	4·13	3·96	2·87
Basic cost / Labour cost %	250	400	290	1600
Floor area required (sq. ft.)	640	1620	2160	1300
Number of skilled operators required	8	22	35	12
Number of unskilled operators required	—	—	—	8
Number of general purpose machines used	5	8	12	4
Number of special purpose machines used	—	5	6	4
Total capital investment (£)	5950	13600	25500	67000
Yearly output (components)	480	4800	11520	19200
Yearly output per skilled operator (components)	60	218	329	1600
Yearly output per £100 capital investment (components)	8·1	35·5	45·2	28·6

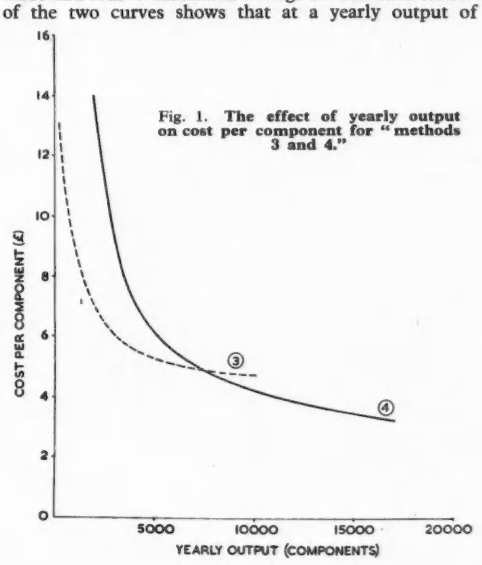


Fig. 1. **The effect of yearly output on cost per component for "methods 3 and 4."**

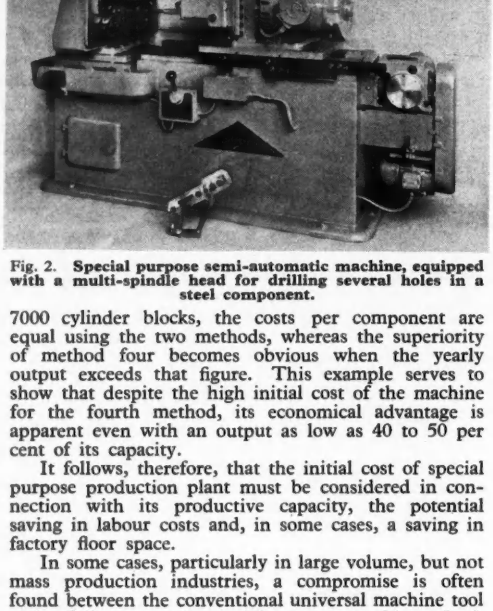


Fig. 2. **Special purpose semi-automatic machine, equipped with a multi-spindle head for drilling several holes in a steel component.**

7000 cylinder blocks, the costs per component are equal using the two methods, whereas the superiority of method four becomes obvious when the yearly output exceeds that figure. This example serves to show that despite the high initial cost of the machine for the fourth method, its economical advantage is apparent even with an output as low as 40 to 50 per cent of its capacity.

It follows, therefore, that the initial cost of special purpose production plant must be considered in connection with its productive capacity, the potential saving in labour costs and, in some cases, a saving in factory floor space.

In some cases, particularly in large volume, but not mass production industries, a compromise is often found between the conventional universal machine tool and a fully automatic special purpose machine Such a case can be illustrated by the following example. A production rate of approximately ten components per hour was required for the drilling and finish-boring of several holes in a drive bearing bracket used in textile machines. When using normal universal machines, the floor-to-floor time was 20 minutes per component, so that three or four machines were needed to provide the required output. These, in turn, necessitated three or four operators and a similar number of fixtures. The cost of a fully automatic machine could not be justified by the relatively small production volume and a compromise solution was evolved, i.e., two special purpose machines as illustrated in Fig. 2, having an automatic cycle, but manual loading and unloading. One was used for roughing with twist drills, whilst the other machine was equipped with boring bars for finishing the bores. The total time for both operations was five minutes, giving an output of twelve components per hour. Due to the automatic cycle, one operator could easily service both machines. The economies resulting from the installation of these machines were such that the additional cost of the special machines was fully justified.

Unit Construction.

The one development which should contribute to the wider application of special purpose machine tools is the introduction of standardised units from which complete machines can be built up. These units are receiving considerable attention on the Continent and the U.S.A., and at least one large user of machine tools in this country has developed special units for use in his own works. In fact, one complete machine shop is already fully equipped with machine tools built up of these units and further ones are being introduced where possible.

Among the many advantages of building up special purpose machine tools from standard units are the following :

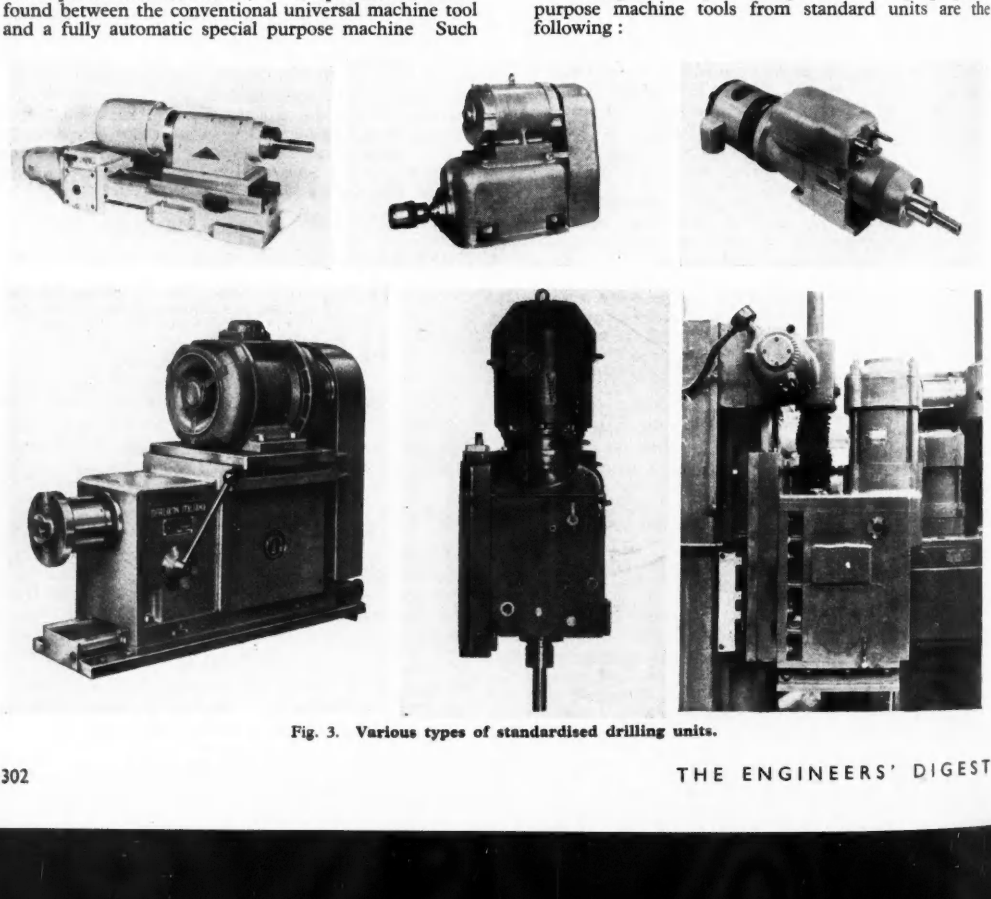


Fig. 3. **Various types of standardised drilling units.**

Machines built up of standardised units are simple and strictly functional. Their cost is lower, due to the incorporation of units built in large numbers.

The time required for the design of special purpose machines is reduced, as much of the design data are available in the form of specifications of standard units.

If standardized units are held in stock, the total time from the design stage to actual operation of the completed machine is relatively short and consists mainly of adaptation, assembly and testing.

Modification or complete change of the product does not involve the scrapping of costly plant. The special purpose machine can be disassembled into the basic units and these can again be built up into special purpose machines to suit the new machining requirements.

As units are normally available in a range of sizes, the special purpose machine built up with these units will incorporate units of the correct size for their task. Large and bulky components requiring only light machining can be dealt with by small unit heads mounted on a heavy base. If the machining were performed on a conventional universal machine tool, the size of the component would determine the size of the machine to be used. In consequence, a heavy machine tool would have to be used and only a fraction of its full capacity would actually be required.

Several manufacturers have developed or are developing complete standardised unit systems, consisting of machining units of various types and auxiliary units providing feed motions, work traverse, indexing, and tables, bases, etc. These units are often produced in a carefully planned range of sizes to cover the machining requirements of a variety of components of different types and sizes. Their construction is based on the experience gathered in the production of universal machine tools and thus often utilises many up-to-date ideas in the design of drives, bearings and controls.

The most frequently used machining unit is the drilling unit. It generally incorporates a built-in driving motor and derives the feed and rapid traverse movements from a separate unit. The separate feeding arrangement not only has the advantage of reducing the individual units to the simplest essentials, but also means that the cutting tool remains at a constant minimum distance from the main spindle bearing, irrespective of the approach length and drilled depth. This results in increased rigidity compared with the normal method, where the spindle itself is fed forward during approach and drilling. Several types of drilling units are shown in Fig. 3. This type of unit, with modifications or additions, can be used for a range of machining operations including simple drilling, deep hole drilling, boring, facing and tapping. Multi-spindle heads are also often mounted on such units as shown in Fig. 4.

Other commonly used machining units include those for milling, turning and special facing units with outfeeding tools. The latter can be combined with drilling or boring units; this combination can then be used where a bore and a face have to be machined at one setting. The outfeeding of the tools is actuated mechanically or hydraulically, depending on the design of the unit. In combination with the longitudinal feed of the unit as a whole, the units are capable of performing many frequently required operations.

Additional units necessary for building up complete machines include table units and base units. The table units are normally available in a range of sizes, the gradation of sizes being sometimes based on a geometrical progression, using this for the table widths as shown in Fig. 5. The table heights are determined in proportion to the widths, whilst the table lengths can conveniently be graded in multiples of the table widths if the ribbing of the table castings is designed to form squares the sides of which are equal to the table width. The tables often incorporate the feed mechanism.

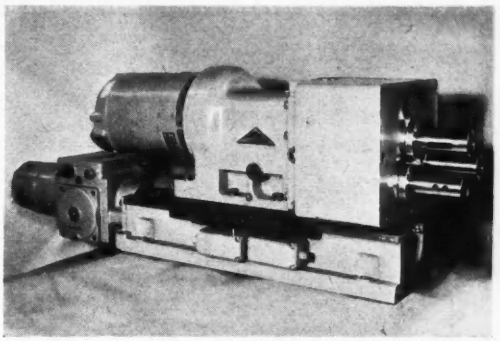


Fig. 4. **Drilling unit equipped with a multi-spindle head.**

The feed arrangement for the machining units is of very great importance as it governs the range of applications of the whole unit-built machine. Apart from purely mechanical systems, which have limited application, the various methods can basically be divided into four main groups, the division being based on the motive power and the control system :

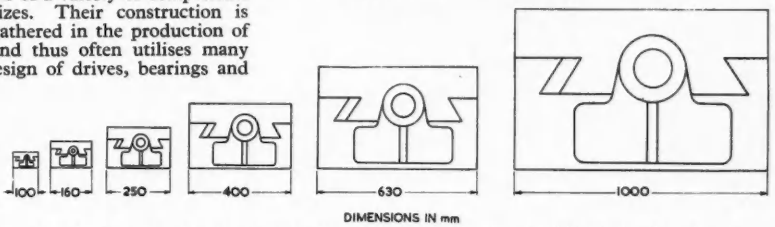


Fig. 5. **A standardised series of table units, the graduation of widths being based on a geometrical progression.**

(1) Electro-mechanical.
i.e., Feed movement electrical.
Feed control mechanical, using stops and trip switches.

(2) Electro-hydraulic.
i.e., Feed movement electrical.
Feed control hydraulic, using hydraulic valves, etc.

(3) Hydraulic-electrical.
i.e., Feed movement hydraulic.
Feed control electrical, using magnetically actuated valves.

(4) Hydraulic-mechanical.
i.e., Feed movement hydraulic.
Feed control mechanical, using stops.

The electro-mechanical method has the advantage of relative simplicity and reliability, and easy maintenance by electricians experienced in servicing normal machine tool electrical equipment. Against that, the hydraulic methods have other advantages, including easy means of stepless adjustment, and the possibility of simultaneous control of hydraulically operated fixtures and of forced lubrication. They are, however, often sensitive to changes in ambient temperature and operating

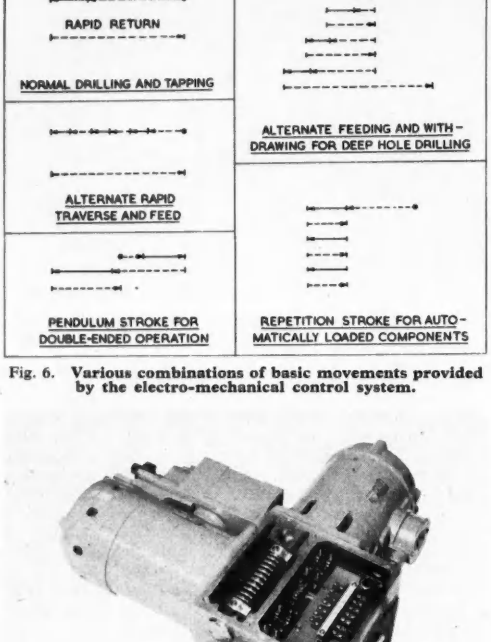

FEED RAPID TRAVERSE
RAPID RETURN
NORMAL DRILLING AND TAPPING
ALTERNATE FEEDING AND WITH-DRAWING FOR DEEP HOLE DRILLING
ALTERNATE RAPID TRAVERSE AND FEED
PENDULUM STROKE FOR DOUBLE-ENDED OPERATION
REPETITION STROKE FOR AUTO-MATICALLY LOADED COMPONENTS

Fig. 6. **Various combinations of basic movements provided by the electro-mechanical control system.**

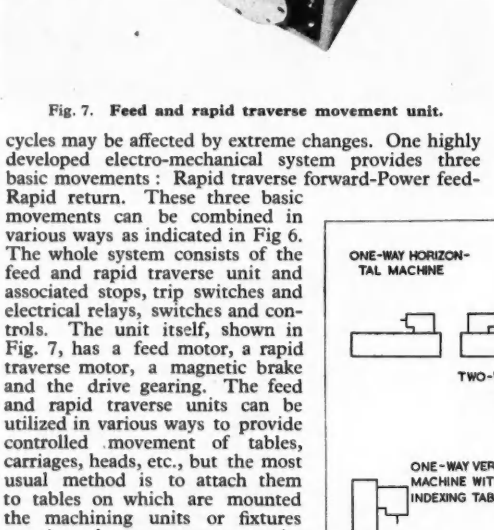


Fig. 7. **Feed and rapid traverse movement unit.**

cycles may be affected by extreme changes. One highly developed electro-mechanical system provides three basic movements: Rapid traverse forward-Power feed-Rapid return. These three basic movements can be combined in various ways as indicated in Fig 6. The whole system consists of the feed and rapid traverse unit and associated stops, trip switches and electrical relays, switches and controls. The unit itself, shown in Fig. 7, has a feed motor, a rapid traverse motor, a magnetic brake and the drive gearing. The feed and rapid traverse units can be utilized in various ways to provide controlled movement of tables, carriages, heads, etc., but the most usual method is to attach them to tables on which are mounted the machining units or fixtures carrying the components to be machined. Such an arrangement is shown schematically in Fig. 8. The adjustable stops A, B and C are set according to the required feed and rapid traverse lengths and actuate the trip switches a, b and c. These, in turn, control the operation of the feed and rapid traverse unit and of the machining unit spindle. The simplest type of machine using such a unit and controls is illustrated in Fig. 9. This shows a small drilling unit of $\frac{5}{8}$ in. capacity, mounted on a table which, in turn, is mounted on a simple base. The base also carries a fixture for holding the component to be drilled. The entire operation is controlled by the three push-buttons on the small control panel attached to the base. An interesting feature of this system is the standardisation of the electrical control equipment, which is also broken down into units that can be used in various combinations.

SPECIAL PURPOSE MACHINES BUILT ON THE UNIT CONSTRUCTION PRINCIPLE.

The various units described above can be combined and assembled in an almost infinite variety of ways to suit the type of component to be machined, the

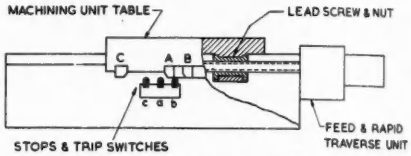


Fig. 8. **Arrangement of feed and rapid traverse unit mounted on a table unit.**

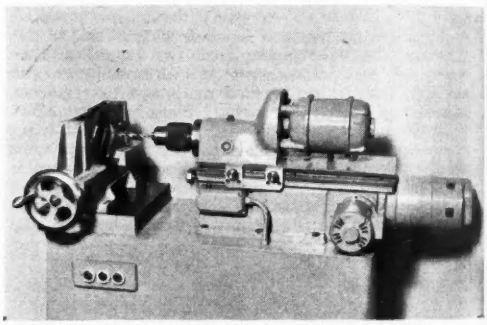


Fig. 9. **Simplest type of unit construction machine.**

machining operations involved and the required output. A selection of typical combinations is shown in schematic form in Fig. 10. An example of the simplest

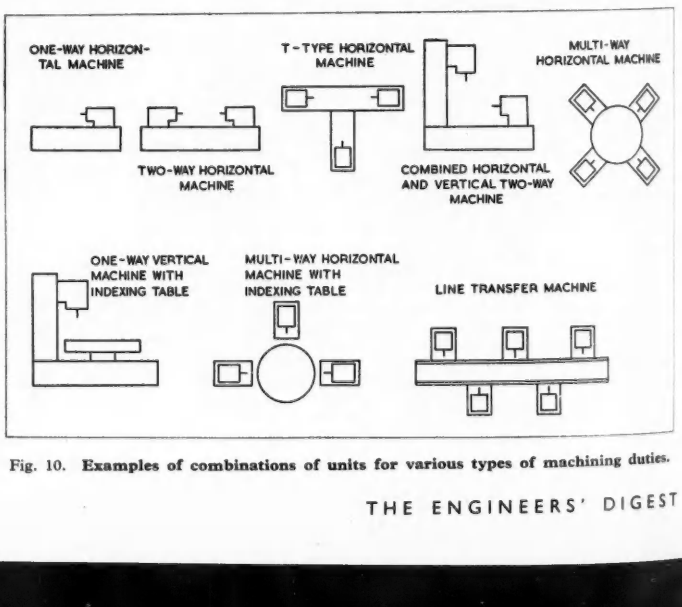

ONE-WAY HORIZON-TAL MACHINE
T-TYPE HORIZONTAL MACHINE
MULTI-WAY HORIZONTAL MACHINE
TWO-WAY HORIZONTAL MACHINE
COMBINED HORIZONTAL AND VERTICAL TWO-WAY MACHINE
ONE-WAY VERTICAL MACHINE WITH INDEXING TABLE
MULTI-WAY HORIZONTAL MACHINE WITH INDEXING TABLE
LINE TRANSFER MACHINE

Fig. 10. **Examples of combinations of units for various types of machining duties.**

form is shown in Fig. 9, referred to above. Machines of this type, or similar vertically arranged machines, are capable of replacing normal drilling, tapping or boring machines with the added advantage of the automatic cycle The operators' duties, apart from the initial setting, are confined to loading and unloading the workpieces and starting the cycle by simple push-button control. A two-way hydraulically operated machine, using one horizontal and one vertical unit, both of which are equipped with multi-spindle heads, is shown in Fig. 11. The heads contain a total of 235 spindles and are used for drilling holes on two sides of a crankcase. The total time required for the entire operation is less than 7 minutes, giving an output of 5 to 7 components per hour, depending on the utilisation efficiency. The machine is easily adaptable should the design of the component be changed, as the multi-spindle heads can be removed and replaced by new ones.

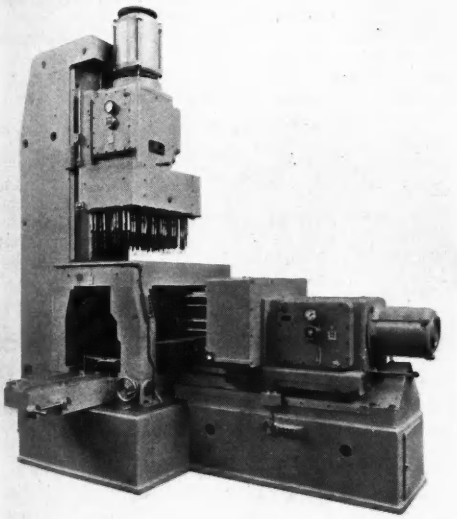
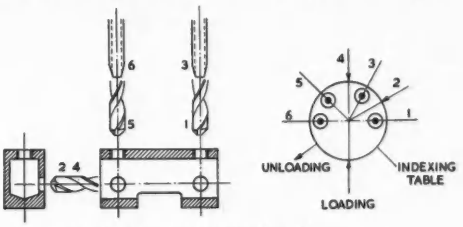


Fig. 11. **Two-way hydraulically operated special purpose machine, with one horizontal and one vertical unit equipped with multi-spindle heads.**

All the machines and units described so far were of the medium or heavy type. The unit construction principle can, however, also be applied to light machine tools and the example selected to illustrate a machine incorporating a circular indexing table is of a very much lighter type, as shown in Fig. 12. It uses light automatic drilling, tapping and milling units in conjunction with the automatic indexing table. Indexing of the table, and feed and rapid traverse of the units are co-ordinated by a system using Bowden type cables, and operation is automatic except for loading and unloading the components. Manual unloading can in some cases be avoided by using automatic ejectors. Very high production rates can be achieved on machines of this type and they are eminently suitable for the mass production of small brass or steel components. The production capacity of machines built on this principle is well illustrated by the example shown in Fig. 13.

Perhaps the most highly developed application of machining units is in the construction of automatic line transfer machines. Although machines of this type often necessitate the use of units and equipment of a non-standard type, they nevertheless come under the heading of unit construction machines. There are several such machines in use in this country, mainly in the automobile industry. Their inherent high initial cost can only be justified in mass production industries, but they have amply proved their efficiency under suitable conditions. Their general construction is illustrated in Fig. 14. This shows a section of a line for machining of cylinder heads. The machining units,

Fig. 12. **Light special purpose semi-automatic machine, incorporating drilling, tapping, milling and indexing units.**



COMPONENT: BOX TYPE TERMINAL (BRASS)

STATION	OPERATION	HOLE DIAS. in.	UNIT	SPEED rpm	LENGTH OF STROKE in.	FEED per rev.	STROKES per minute
1	DRILL CORE HOLE	0·162	VERTICAL DRILLING	5800	0·475	0·0032	32
2	DRILL	0·162	HORIZ. DRILLING	5800	0·475	0·0032	32
3	TAP	0·198	VERTICAL TAPPING	1100	—	—	32
4	DRILL	0·162	HORIZ. DRILLING	5800	0·475	0·0032	32
5	DRILL CORE HOLE	0·162	VERTICAL DRILLING	5800	0·475	0·0032	32
6	TAP	0·198	VERTICAL TAPPING	1100	—	—	32

OUTPUT: 30 COMPONENTS PER MINUTE

Fig. 13. **Typical application of a light multi-unit special-purpose machine tool.**

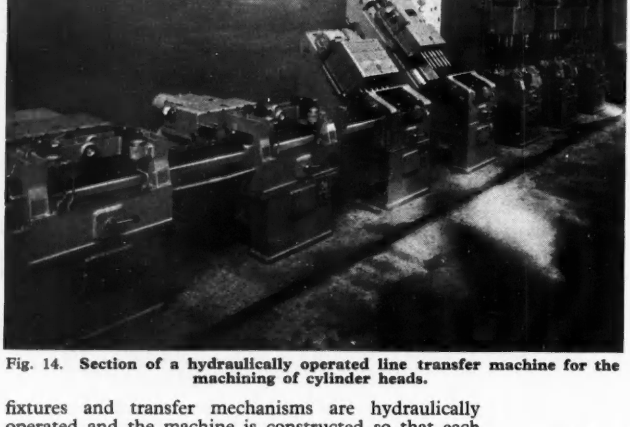


Fig. 14. **Section of a hydraulically operated line transfer machine for the machining of cylinder heads.**

fixtures and transfer mechanisms are hydraulically operated and the machine is constructed so that each unit, fixture and each unit of the transfer mechanism can be controlled individually. Each unit can, moreover, be used separately as a self-contained machine. The whole line consists of twelve machines and a total of 192 machining operations is performed. The cycle time of the line is 1½ minutes, corresponding to an hourly output of 40 cylinder heads.

CONCLUSIONS.

The increasing use of special purpose machine tools, that is, of machines built for a particular machining task, seems to be assured because of their efficiency and labour saving. Their use will in many cases enable the employment of semi-skilled labour instead of the highly skilled labour often required for operating universal machine tools. This advantage will become increasingly appreciated with the dwindling availability of skilled machine shop operators. The pressing need for increased output from a given number of productive personnel is also to a great extent satisfied by efficient special purpose machine tools. The main obstacles to the more general introduction of such machines have hitherto been the relatively high initial cost and the danger of early obsolescence due to changes in product design. Both these objections are to a great extent met by the development of standardised units for building special purpose machine tools. The functional design and large quantity production of these units should eventually result in lower prices, and it is conceivable that units will then be held in works stores, as tools are to-day. The units themselves, being self-contained and universal, do not lose their value when the design of components and machining requirements change. They can be re-used in newly designed machines with a minimum of additional capital outlay. Furthermore, the large users of machine tools can, within their own organisations, design and construct special purpose machine tools exactly suited to their requirements, by employing basic units purchased from specialist suppliers. The use of simple, standardized machine tool units is also in line with the present desirable general trend towards standardisation and simplification in industry. The constant development in the techniques of electrical, electronic and hydraulic control systems should also contribute to establishing the advantages of the unit construction principle in machine tool design.

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ACKNOWLEDGMENTS

Full acknowledgment is made for their kind assistance and provision of photographs, to J. WOLLENHAUPT of Honsberg, and to HAHN & KOLB and their U.K. Agents, MACHINE SHOP EQUIPMENT LTD. Thanks are also due to LLOYD & ROSS LTD. (Burkhardt & Weber), ELGAR MACHINE TOOL CO. LTD. (Oerlikon Italiana), SIDNEY G. JONES LTD. (Kingsbury Machine Tool Corporation), GASTON E. MARBAIX LTD. (Rockwell Manufacturing Company), and the AUSTIN MOTOR CO. LTD., for the provision of photographs.

MODERN MACHINE TOOL MANUFACTURING METHODS

(*Concluded from page* 295)

SLIDEWAY GRINDING.

The slideway grinding of rubbing surfaces is widely practised in machine tool manufacture nowadays, and the question of distortion again crops up continuously.

As the slideway grinding operation is merely a form of mechanical scraping, the casting can be securely held on the machine table without the use of holding down clamps, endwise and sidewise movement being prevented by the use of suitable stops.

The weight of the casting itself is generally sufficient to withstand any movement likely to be caused by the pressure of the grinding wheel, and thus with a suitable grade of wheel very fine accurate finishes can be obtained.

FITTING AND ASSEMBLY.

In former days, indifferent machining was rectified by the use of hand tools by skilled fitters. Today the scraper is generally sufficient to correct the minute inaccuracies in modern method machining, and so the erection of a machine is practically reduced to assembly work, making what used to be the most difficult and expensive part of manufacture a relatively simple process.

GENERAL

Thus, by careful attention to the various points raised in this paper, it is possible to produce, even under the exacting cost conditions of today, a relatively cheap machine of a high standard of workmanship and first-class performance.

Photoelastic Investigation of Transversely Loaded Plates by the Double-Layer Method

By A. KUSKE. (From *Zeitschrift des V.D.I.*, Vol. 94, No. 22, August 1, 1952, pp. 745-747, 10 illustrations.)

THE stresses in transversely loaded plates can be investigated photoelastically by the following methods :

(a) *The frozen-stress method.* The transparent stress-optical model is heated, then loaded and left to cool slowly under load. The loading stresses remain "frozen" in the model after removal of the load, and the optical qualities remain unchanged. Slices of the model can now be investigated in the usual two-dimensional manner of photoelasticity, and the stresses can be determined at any point of the model.

(b) *The method of superposition*[1]. A linear (one-dimensional) state of stress is first frozen into the model and the transverse bending load then superimposed. At points where the stress directions of the two states of stress include an acute angle, the optical effects of the compression and the tension sides do not cancel. The resulting effect, though different from the normal two-dimensional stress pattern, gives an indication of the bending stresses.

(c) *Scattered light*[2]. Light scattered by cloudy inclusions in a transparent model is plane-polarised. Scattering thus acts as its own polariser or analyser in the interior of the model and permits the determination of three-dimensional stress patterns, and hence also the determination of stresses in transversely loaded plates.

(d) *Reflected light.* A transparent stress-optical layer or sheet is attached to a mirror surface of an opaque body, or a mirror foil is interposed between two transparent sheets[3]. The light is reflected at the mirror surface and travels twice through the transparent sheet. If the mirror surface is placed at or near the neutral axis of bending, only the tension or the compression side is used for the optical effect and stress patterns similar to those of two-dimensional photoelastic analysis are obtained.

(e) *The mathematical analogy*[4]. A mathematical analogy exists between the stresses in a plate loaded by forces in its own plane and the stresses in the same plate under transverse loads. The results of a two-dimensional investigation can thus be applied to the transversely loaded plate.

(f) *The double-layer method*[5]. Two transparent sheets having different stress-optical coefficients are bonded together. The stress-optical effects of the tension and the compression side then do not cancel. The resulting effect is similar to that obtained in two-dimensional photoelastic analysis and gives an indication of the bending stresses, for instance, at the model surface. These stresses are proportional to the imposed bending moments. The stress-optical effect may be evaluated either from point to point by means of Favre's interferometer arrangement or, if several fringes appear in the model, by observation and photography of the entire model area as in two-dimensional photoelasticity. Glass and stress-optical plastics do not bond well; higher stresses can be employed and better results obtained if two different transparent plastic materials are used, one with a low optical sensitivity (plexiglass), the other with a high sensitivity (P-F or polyester resins). The bond is best made with plexigum KP 8013. Very good models have also been obtained by casting a layer of liquid polyester resin on plexiglass.

EVALUATION OF DOUBLE-LAYER PHOTOELASTIC STRESS PATTERNS

As in two-dimensional investigations, fringes and isoclinics are observed. The fringes represent the difference in the principal stresses at the surface of the transversely loaded plate; the isoclinics permit determination of the stress trajectories, i.e., the directions of the principal stresses. At the free boundaries of the plate, the magnitude of the principal stresses is directly given by the fringes. At inner points of the plate surface, the magnitude of the principal stresses must be determined by other methods based on the equilibrium and compatibility equations, by Favre's optical interferometer method, by means of a conoscope, or by drilling a small hole at the point under consideration so that the stress distribution at the edge of the hole is known. As in all stress investigations, we may assume from experience that the stresses are proportional to the imposed loads and inversely proportional to the square of the linear dimensions of the model or full-size component. The photoelastic results can thus be transferred to the full-size component to be investigated. Within certain limits, the cross-sections of a plate bent by transverse loads remain plane so that the stress distribution is linear over the cross-section. With otherwise equal dimensions, the stresses at the

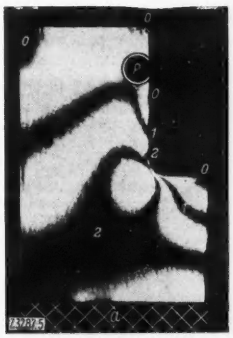

Fig. 1

Fig. 2

Fig. 1. Stress pattern of a cantilever plate built-in at *a*, transversely loaded at *P*, with width reduced at midlength. Crossed polariser and analyser.

Fig. 2. Stress pattern of plate Fig. 1, with parallel polarizer and analyser.

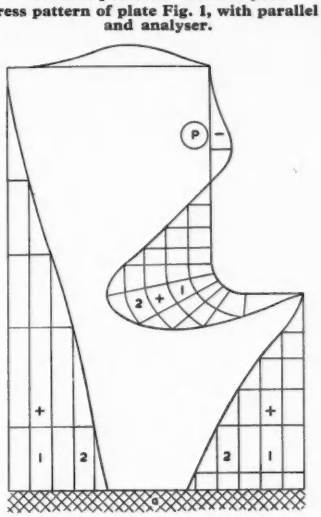

Fig.3. Stress distribution along the edge of the plate Fig. 1.

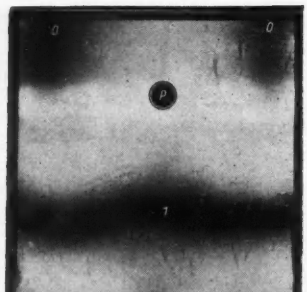

Fig. 4 (left). **Stress pattern of a rectangular cantilever plate with transverse hole. Plate built in at *a* and loaded transversely at *P*. Crossed polariser and analyser.**

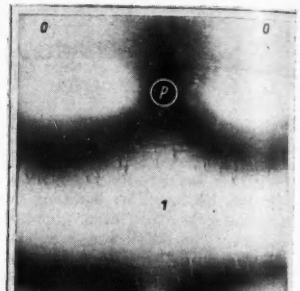

Fig. 5 (right). **Stress pattern of plate Fig. 4, with parallel polariser and analyser.**

surface are therefore inversely porportional to the square of the plate thickness. However, results observed on models can strictly be transferred to full-size components only if Poisson's ratio is the same for the model and the full-size material. The influence of different Poisson's ratios has not yet been fully investigated, but should, in general be small. For a plate with a central hole, Neuber has found a maximum difference of 10 per cent in the stresses if the ratio changes from the maximum (0·5) to the minimum (zero) possible value. For ordinary values of the ratio, the difference should not exceed 5 per cent. Moreover, Poisson's ratio for photoelastic model materials (0·33) is a good average of the values of all the materials used in practice and lies particularly near the value for steel (0·3). It thus seems justifiable to ignore this influence.

The accompanying photographs of stress fringes taken in monochromatic polarised light show a few results obtained for plates fixed at the lower edge *a* and loaded by a concentrated transverse force at *P*. Each dark fringe line is a line of constant stress, and the stresses change by the same amount from line to line. The figures in the photographs indicate fringe values or stress ratios ; if the coefficients of the model material have been determined by a calibrating test, the absolute magnitude of these stresses can easily be calculated. Photographs taken with a parallel polariser and analyser show the full fringe values as dark lines, whereas the half-fringes appear as dark lines when polariser and analyser are crossed. A more accurate evaluation is thus possible if both sets of stress patterns are observed. In the photographs shown here, the load was always placed on the side of the less sensitive plexiglass so that stress disturbances near the point of loading are hardly noticeable. If the load is placed on the sensitive layer, disturbances can be observed and are more pronounced, the thinner the sensitive layer is in comparison with the thickness of the plexiglass sheet. Disturbances expected from the shear stresses in planes parallel to the plate surface were practically absent.

Figs. 1 and 2 show a cantilever plate reduced in width at midlength. In contrast to the results of two-dimensional stress analysis, the principal stress difference due to bending has a maximum, not at the boundary, but at a small distance from the transition radius. Fig. 3 illustrates the evaluation of the boundary stresses in this plate from the photographs 1 and 2. Figs. 4 and 5 show a centrally loaded cantilever plate with a central transverse hole. The stress concentration factor at the hole can be calculated theoretically for an infinite plate in pure bending.[6] The maximum theoretical value is 1·8, and the value found from the photographs is also about 1·8 (i.e., 3·9 max. fringe value at hole divided by 2·15 average fringe value in the same cross-section). Fig. 6 finally illustrates the

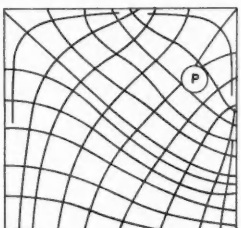

Fig. 6. **Stress trajectories plotted from isoclinics observed in a cantilever plate built in at *a* and transversely loaded by a concentrated force applied at *P* near the side of the plate.**

stress trajectories at the surface of a cantilever plate with eccentric transverse loading, as found from observation of the isoclinics. Inside the plate, the trajectories are approximately parallel to those at the surface. A third set of trajectories is normal to the plate surface. In several points, the surface trajectories, due to transverse bending, deviate from the principles ordinarily expected in two-dimensional stress analysis.

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Soviet Machine Tools

By J. MANNIN

In this contribution the author continues his review of recent advances and current developments in the Russian Machine Tool Industry. The first part of this review appeared in our issue of last month and included a discussion of "speed cutting." Our next issue will continue the survey with an appreciation of Soviet machine tools outside the metal cutting field. Production machinery using the casting, forging, pressing and welding processes will be dealt with.

It is interesting to observe the announcement of the general qualities in new designs of standard types of machine tools.

A newly brought-out machine would be claimed to possess greater power, increased stiffness, automatic clamping arrangements, single lever control, automatic selection of speeds and feeds, centralised automatic lubrication and protected working surfaces, a list repeated in any sales pamphlet of a reputable British or American manufacturer.

The following list of advanced designs will illustrate current developments in Russian machine tool manufacture :—

A die-sinking machine was brought out in 1948 which incorporates an electronically controlled follow-up system with an electro-magnetic pick-up element. The machine is claimed to be an advance on the "Keller" design.

A thread-grinding machine with a pendular grinding spindle appeared in 1948 and was claimed to be on the level of the most advanced in the world.

A number of machines for axle and wheel set turning in the locomotive and wagon industry were brought out in 1949. These machines ensure semi-automatic work and relieve the operator of all heavy manipulation.

Also in 1949, special machines for globoid worm milling (for motor car steering mechanisms) were operating successfully.

The production of "Gleason" type bevel gear shaping machines is announced in 1952 in the description of an original design. In the same year a semi-automatic spur gear grinder said to be more universal than any European type has been brought out.

Also this year, the production of infinitely variable mechanical transmissions* incorporating ball friction elements and transmitting 3 hp has been started.

Advanced types of pneumatic gauges, surface roughness recorders, and special microscopes for the inspection of the "microgeometry" of cutting edges, are in current production.

Some technical points of interest among the discussions in current professional literature and at meetings are selected. Considerable attention is devoted to the control of spindle speeds. Electronic means of driving motor control have been embodied in several experimental designs, though not yet in production machines. The control of induction motors by means of magnetic amplifiers has been proposed. On the other hand, it is pointed out that present knowledge of the cutting process does not necessarily justify infinite variation of speeds.

Improvements and reduction in cost of cutting tool production form the centre of attention. Casting to finished dimensions of high-speed steel milling cutters is recommended. High-frequency induction hardening of high-speed steel tools is discussed, as well as the use of sub-zero temperature methods in their heat treatment. The mechanised manufacture of master cams for multi-tool cam shaft lathes is suggested by the inventor of a special fixture for this purpose.

Some unusual and advanced production processes are studied, such as the machining of integral pins of complicated components by means of an enveloping milling cutter, the cold rolling of thread surfaces for improved fatigue resistance, the use of rotating discs as single-line cutting tools, and the geometry of "tangential" cutting tools.

Technical points in the design and manufacture of machine tools are given some prominence, such as optical inspection methods in the assembly of jig borers, acceptance tests for lathes based on surface quality of work, routine supervision of accuracy in gear-cutting machines, the benefits from the superfinishing of spindles running in sliding bearings, the causes of inaccuracy in very large machine tools, the design of feed mechanisms with rolling friction only.

Other contributions cannot easily be classified. Attention is now paid to the appearance of machine tools under the heading of "Architecture." The problems of chip breaking and chip removal mount with increases in productivity of cutting and automatic means for chip handling become more important. Much ingenuity has gone into standardised jigs and fixtures. These examples show that work is proceeding on a large variety of problems and the list could be extended *ad infinitum*.

Among scientific investigations, those concerned with the study of the cutting process and the geometry of cutting edges form a large proportion. The quest for optimum cutting conditions continues unabated. Investigations range from physical fundamentals to comparative evaluation of tool materials, and the relations between the geometry of the tool and the component in the machining of threads and gears. It is under this heading that the most acrimonious discussions are found on Soviet priority in the discovery of the laws of cutting. Experimental work in this field has led to the development of several types of dynamometers which measure the various components of cutting forces.

The introduction of "speed cutting" has, in many cases, brought existing machine tools to the limit of their capacity for withstanding vibrations. The study of vibrations in machine tools is pursued from many angles. Next to the discovery of resonant conditions in spindles and components, the existence of "relaxation oscillations"† in feed mechanisms has been revealed and studied. More generally, the elastic properties of large and small elements of machine tools have been systematically examined. Heat deformations and their effect on machine tool operation have been studied. In experimental work, electro-magnetic and crystal pick-ups for vibration recording have been developed.

Copying methods of tool guidance assume increasing importance in production machining and die-sinking. The kinematic principles of existing and unexplored copying lathes have been discussed. Some detailed problems of hydraulic follow-up mechanisms have been studied, as well as the design problems of electrical copying attachments.

The foundations and practical problems of measurement and measuring instruments have been investigated, such as the basic mechanism of the micrometer, the fundamental properties of complicated lever mechanisms employed in measuring instruments, some problems of flexure pivots, and the systematic errors in surface roughness recorders.

An investigation characteristic of present trends in Russia is the fundamental examination of the rational basis of standardisation. It appears that the statistical method hitherto followed is not correct and must be replaced by a more logically coherent system, such as

* See *The Engineers' Digest*, July 1950, pp. 239-40.

†See "An Analysis of Feed Mechanisms in Machine Tools," pp. 298-300 in this issue.

the acceptance of basic laws of progression. This brings us to the borderline field between technology and economics, in which much original work is done in Russia (Section 5).

The importance attributed in the Soviet Union to technical literature can be gauged from the space devoted in periodicals to book reviews in this particular branch of engineering. Reviews are thorough and often devastating. In one case, the discussion of an important work was made the subject of a trade conference. It was announced in the name of the highest authority that "no science can develop without a struggle of opinion, without freedom of criticism." The book was torn to pieces and declared incompetent and even misleading. The report closes by saying that the authority in question "has accepted a number of administrative proposals following from the general appraisal of Professor Shaumyan's book."

Finally, we can record a number of achievements of the Russian machine tool industry which for their novelty can be considered outstanding. Among fully developed production machine tools we find some without equivalent in other countries. An automatic lathe was put into production in 1948 for work from bar stock, in which the sequence and progress of operations is controlled without cams by means of an electro-hydraulic mechanism. A surface grinder was brought out in 1951 which performs two-face grinding upon components passing between the faces of two sets of cup wheels. The components are not clamped and the grinding operation is therefore reminiscent of centreless grinding on cylindrical surfaces.

Several novel methods of cutting are under development in the Soviet Union. Probably the most promising is electric spark cutting, in which a stream of sparks due to an electrical discharge between the component and the cutting electrode performs the same function as the oxygen flame in oxygen cutting. Another method of material removal without contact is described as anodic-mechanical. In this method, the component, usually a tool, has the same function in the circuit as a component in an electric polishing bath. Finally, some progress has been made with the abrasive liquid machining of production components*. A stream of abrasive liquid under pressure is directed against the surface to be machined and causes removal of metal from the surface. By this method, otherwise inaccessible surfaces can be machined, and the control of the process is surprisingly good.

Other innovations showing good promise are the high-frequency induction hardening of cast iron guide faces which can be performed on certain classes of high-strength cast iron. The use of a plastic mass† acting like an incompressible hydraulic fluid, in clamping devices, is becoming widespread.

Perhaps the most important novelty in the Russian machine tool industry is the introduction of unit type construction into some of its special machine tools. This branch of Russian machine tool construction has become a pet of political and economic theorists, and its engineering significance must be disentangled from the embrace of confusing slogans. It is a good sign for the competence and sagacity of Soviet engineers that we can do so entirely on the strength of their own publications.

Linguistically, the Russian word "aggregate" is sometimes taken over bodily by non-Russian reviewers. This practice does not contribute to clarity. The meaning of "aggregate" in the Russian sense is "assembly," and its employment in the present context denotes "standardised sub-assembly" or unit. It is important that these units are both self-contained and standardised. Russian designers have in some instances succeeded in producing universal machine tools built up from self-contained but not standardised units. Unit-type machines are special machine tools built-up from self-contained and standardised units. A determined effort is made in the Soviet Union to design as many of the specialised machine tools as possible on the basis of unit-type construction.

The principles which guide this effort are fundamental and well-appreciated by tool engineers everywhere. In Russian professional literature there is little trace of the fantastic claims and world-shaking predictions made in some popular accounts. An authoritative Russian source states that the employment of unit-type construction is appropriate in tooling-up for the manufacture of mass-produced precision components requiring multi-tool machining. The advantages of the system are listed as follows :—

(a) Reduced tooling time.
(b) Reduced cost of machinery.
(c) Guaranteed functioning.
(d) Relative ease of repeated modification and modernisation of separate elements.
(e) Simplification of maintenance and repair.
(f) Easy installation of fully automatic production.
(g) Possibility of increasing the number of operations.
(h) Easier accommodation of modified product components.

Unit-type machines are employed mainly when simultaneous machining of many surfaces is possible, or at least many more than could be dealt with on universal machine tools. Another important condition is the ability to use tools with a long life. Some economic criteria which determine the advantages to be gained from unit-type construction will be discussed in the subsequent section.

By 1950, technical development had reached the following stage. Fully developed units were available for drilling, boring, and milling operations. These units are confined to a single direction of tool advance and destined for the machining of components which remain stationary during the cutting process. The development of standard units which can be applied to moving components and those requiring complicated motion of the cutting tool forms part of the development programme facing Russian designers.

Actual components produced under the scheme comprise the following categories :—

(1) Frames and beds.
(2) Multi-spindle head for drilling, boring and milling tools.
(3) Power units for spindle drive.
(4) Powered feed units.
(5) Hydraulic feed units.
(6) Units for component clamping.
(7) Units for transport of components.
(8) Control units.

Examples of all these units have been described in Russian technical literature. On the whole, lay-out and detail design are orthodox. It was not possible to select striking innovations which would distinguish Soviet designs from those elsewhere but modern principles of detail design are certainly upheld in these structures and mechanisms.

Often, the unit-type machine tool has been used in so-called automatic production lines, but the combination is neither inevitable nor always useful. Soviet engineers proceeded early with the establishment of fully automatic production lines. In isolated cases, such production lines have shown great benefits, although, of course, such claims as the reduction of machining time from 195 to 3½ minutes are based on nothing more than confusion of actual machining time of a component with the cycle time of a production line.

Much ingenuity has been devoted to fully automatic transport arrangements and clamping devices, but it is

(*Continued on page* 316)

* See *The Engineers' Digest*, November 1951, pp. 365-368.
† See *The Engineers' Digest*, April 1952, pp. 109-112.

The Significance of the Thermal Number in Metal Machining

By B. T. CHAO and K. J. TRIGGER. (From Paper No. 52-SA-58 presented at the Semi-Annual Meeting of the *American Society of Mechanical Engineers*, June 15-19, 1952, 14 pages, 10 illustrations.)

The theoretical analysis of heat flow in conjunction with cutting data in high-speed orthogonal metal machining operations shows that, for a given tool rake, the temperature distribution along the shear plane is solely dependent on the thermal number $V_c\, t/k$. An explanation is offered for the difference in chip curvature as the cutting conditions are changed. Further significance of the thermal number in metal machining is presented.

INTRODUCTION.

Most of the energy expended in metal cutting is converted into heat and distributed in the tool, chip and workpiece. A close relation exists between the mechanism of chip-formation and the tool—chip interface temperature.[1,2] This temperature also plays an important role in the life of the cutting tool.

In orthogonal cutting operations, the shear zone constitutes essentially an oblique band source of heat, moving in the direction of the cutting velocity vector through the metal of the workpiece. The problem of the calculation of the temperature field in a solid due to moving sources of heat has been treated by a number of authors.[3,4] Recently the analysis has been extended to a two-dimensional case, where the plane of the band source is inclined to its direction of motion in an infinite medium.[5] These results have been applied in the present work to the calculation of the temperature distribution along the shear plane, using a slightly different derivation.

TEMPERATURE DISTRIBUTION ALONG THE SHEAR PLANE IN ORTHOGONAL CUTTING OPERATIONS.

Referring to Fig. 1, the co-ordinate axes x and y are fixed in space with the origin coincident with the mid-point of the shear zone at the time $\tau = 0$. ξ and η are a moving pair of axes travelling with the source.

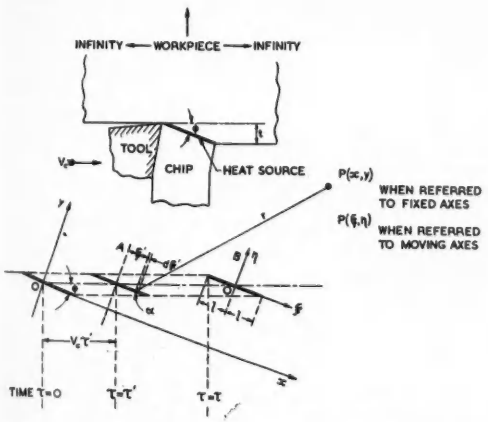

Fig. 1. **Moving band source of heat due to main chip shear in orthogonal cutting process.**

Within normal speed and feed ranges for carbide tools, the processes of heating are quasi-stationary in nature, and the objective is to find this quasi-stationary distribution along the shear plane. The first step consists of calculating the temperature rise at any point $P(\xi, \eta)$ due to the continuous heating of the moving source when the latter occupies the position B, i.e., τ sec after heating starts. The required expression for the quasi-stationary temperature can then be obtained by investigating the limiting case, when $\tau \to \infty$.

The main steps of the calculation are as follows:

(1) The temperature rise at P (see Fig. 1), at an arbitrary instant τ', due to an instantaneous line source of heat is written down, using the co-ordinates ξ and η.

(2) The final temperature rise $\Delta\theta$ at P can then be obtained by integrating between $-l$ and l, and between 0 and τ, then letting $\tau \to \infty$.

(3) As the temperature distribution in the shear plane is of prime interest, this is found by putting $\eta = 0$. The result, after some simplification and substitution, is

$$\frac{\pi}{2}\frac{c\rho\mathcal{J}}{S_s}\Delta\theta = \frac{\beta}{\cos\phi + \sin\phi\tan\alpha}\left\{ I\left[L\left(\frac{\xi}{l}+1\right)\right] - I\left[L\left(\frac{\xi}{l}-1\right)\right]\right\} \quad .. \quad .. \quad (1)$$

where c = average specific heat of work material,
ρ = density of work material,
$\mathcal{J}$ = mechanical equivalent of heat,
S_s = dynamic shear stress of work material,
β = fraction of heat generated at shear zone conducted back into workpiece,
ϕ = shear angle,
α = tool rake,

$$I(p) = \int_0^p e^{-u\cos\phi} K_0(|u|)\, du,$$

$$I(-p) = -\int_0^p e^{u\cos\phi} K_0(|u|)\, du,$$

$$L = \frac{Rt}{4\sin\phi},$$

R_t = thermal number $= V_c\, t/k$,
V_c = cutting velocity,
t = thickness of "chip" before removal from workpiece,
k = thermal diffusivity of work material $= \dfrac{K}{c\rho}$,
K = average thermal conductivity of work material,

$$u = \frac{V_c(\xi - \xi')}{2k}, \text{ and}$$

$$K_0(m) = \int_0^\infty \frac{dz}{z}\exp -\left(m^2 z^2 + \frac{1}{4z^2}\right),$$ the modified Bessel function of the second kind of zero order.

The two definite integrals $I(p)$ and $I(-p)$ have been evaluated numerically for various values of the shear angle. The results are presented graphically in Figs. 2 and 3, and can be used directly in eq. (1) for the calculation of temperature distribution.

Since in most metal cutting literature, S_s is usually

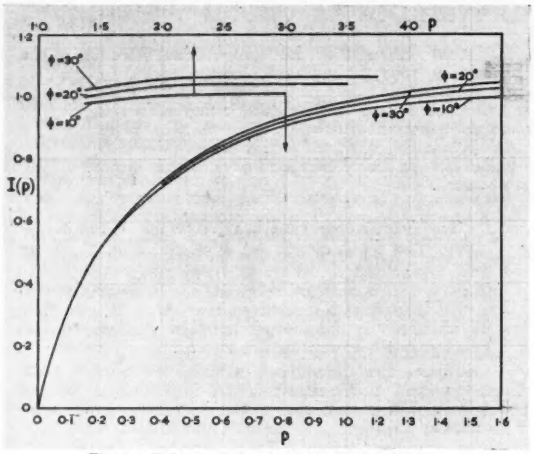

Fig. 2. **Values of the definite integral $I(p)$.**

given in lb/in², $\mathcal{J}$ in ft-lb/BTU, c in BTU/lb-°F, ρ in lb/ft³ and θ in °F, eq. (1) in these units becomes:

$$8{\cdot}5\,\frac{c\,\rho}{S_s}\,\Delta\theta = \frac{\beta}{\cos\phi + \sin\phi\tan\alpha}\left\{ I\left[L\left(\frac{\xi}{l}+1\right)\right] - I\left[L\left(\frac{\xi}{l}-1\right)\right]\right\} \quad .. \quad .. \quad (1')$$

In commercial high-speed metal cutting, the dynamic flow stress S_s can be regarded as a constant, except as modified by the size effect at very small feeds.[2] It has also been found that with a given tool rake, the shear angle is uniquely determined by the thermal number. Fig. 4 shows a plot of the experimental data for cutting spheroidized SAE 52100 steel* with a triple carbide tool of negative 2 deg. rake angle. The thermal diffusivity of SAE 52100 steel at room temperature has been found to be 1·03 in²/min from data in the Metals Handbook.[6]

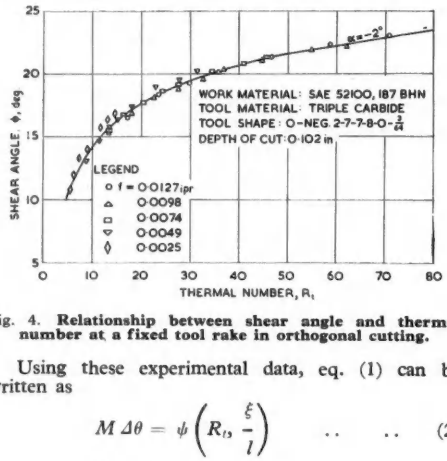

Fig. 4. **Relationship between shear angle and thermal number at a fixed tool rake in orthogonal cutting.**

Using these experimental data, eq. (1) can be written as

$$M\,\Delta\theta = \psi\left(R_t, \frac{\xi}{l}\right) \quad .. \quad .. \quad (2)$$

where $M = \dfrac{\pi}{2}\dfrac{c\,\rho\,\mathcal{J}}{S_s}$ is constant with respect to the cutting variables V_c, t and α.

*0·95–1·10 C, 0·2–0·5 Mn, 0·03 P, 0·035 S, 1·2–1·5 Cr.

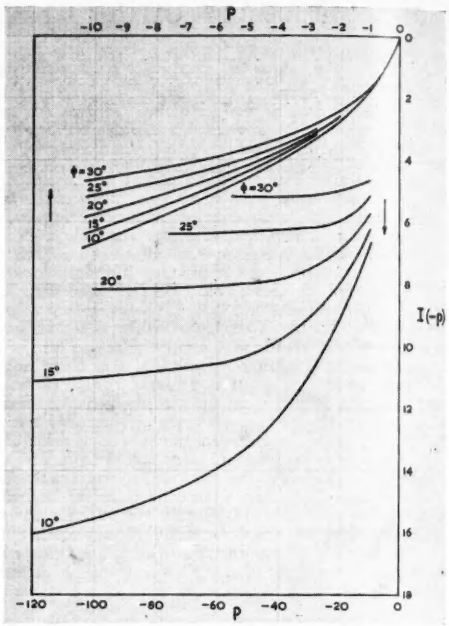

Fig. 3. **Values of the definite integral $I(-p)$.**

ψ designates a possible functional relationship.

This shows that the temperature distribution along the shear plane under ideal conditions is a function of the (dimensionless) thermal number alone.

The fraction β is, unfortunately, not quantitatively known at present. It will normally vary with cutting speed, feed, ratio of the size of cut to the diameter of the workpiece, etc. Its evaluation is made difficult by the fact that part of the heat which flows into the workpiece by conduction will be removed in the chip cut in the succeeding revolution. For orthogonal cutting, the fraction depends on the thermal number: the larger the number, the smaller the proportion of heat to the workpiece.

In operations employing sintered carbide tools and working at relatively high cutting speeds, the change in β is usually not very great. However, because of lack of quantitative data for single point turning, relating β to R_t, eq. (2) is modified slightly, when the effect of cutting speed and feed on the temperature distribution along the shear plane is sought. Thus,

$$\frac{M\,\Delta\theta}{\beta} = f\left(R_t, \frac{\xi}{l}\right) \quad .. \quad .. \quad (2a)$$

No generality is lost, if one bears in mind that β is itself a function of R_t. Fig. 5 illustrates how the cutting speed and feed affect the shear plane temperature distribution in terms of the thermal number. The curve was calculated from eq. (1) with the aid of Figs. 2 and 3 for the value of the integral I, and Fig. 4 for the appropriate shear angle at various thermal numbers. Cutting data were obtained by dry turning spheroidized SAE 52100 steel (187 Bhn) and using wide ranges of speeds. Details of test procedure have been reported earlier.[2]

It is seen from Fig. 5 that cutting at high speeds and large feeds will result in a large shear angle and a much more uniform temperature distribution along the shear plane. Also, the higher the speed, the shallower will be the depth of temperature penetration in a

direction perpendicular to the plane of the heat source. With an excessive negative rake tool (where ϕ is usually small) cutting at relatively slow speeds, the phenomenon described above of the effect of the thermal number on the shear plane temperature distribution might ultimately reverse itself. It is doubtful, however, whether such an extreme case would be met with in practice.

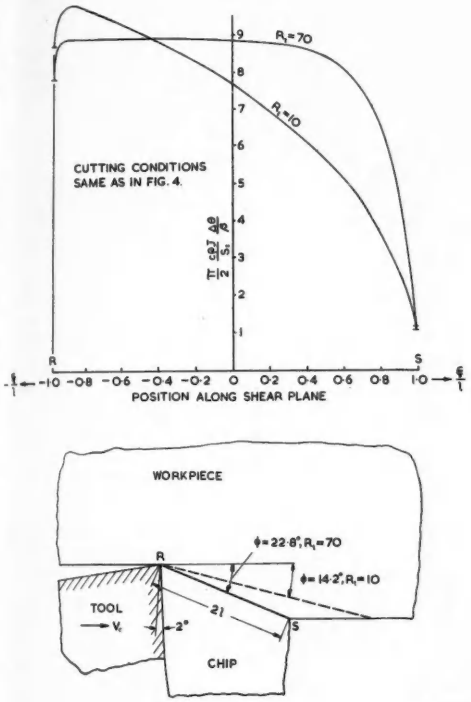

Fig. 5. **Effect of thermal number on temperature distribution along shear plane.**

The effect of the thermal number on the shear plane temperature distribution may serve as a clue to explain the change in curvature of type 2 chips as cutting speed or feed is varied. At a relatively low cutting speed, the non-uniformity of temperature distribution will result in a greater differential volumetric expansion of the material at the back of the chip. Consequently, the chip produced will be of larger curvature than with a more uniform temperature distribution. There are, of course, other factors, such as bending of the chip due to pressure of the tool face etc., influencing the degree of chip curl.

The significance of the thermal number in metal machining has been reported earlier.[2,7] Of practical interest is the fact that there exists also a functional relationship between this number and the energy expended in cutting per unit volume of metal removed. This latter quantity has often been used to designate the efficiency of a machining operation. Fig. 6 shows that the specific work done in metal removal decreases as either cutting speed or feed or both are increased. At equal cutting speeds and feeds, a positive rake tool was found to have a higher efficiency than a negative (2 deg.) rake tool. This greater efficiency may, however, be offset in certain operations by the reduced mechanical strength and thermal capacity of the tool edge.

It appears that a better understanding of metal cutting processes is possible when the full significance of the thermal number is appreciated. The correlation of the various obvious "shear zone" phenomena with the thermal number is very satisfactory.

The same correlation does not exist between the thermal number and the tool—chip friction behaviour. This lack of correlation is thought to be due to changes in friction behaviour as influenced by temperature, and in the temperature-dependent properties of the chip material with steep temperature gradient. The tool—chip interface temperature is influenced to a marked degree by the tool—chip friction aspects, and such frictional behaviour is not solely dependent upon the thermal number.

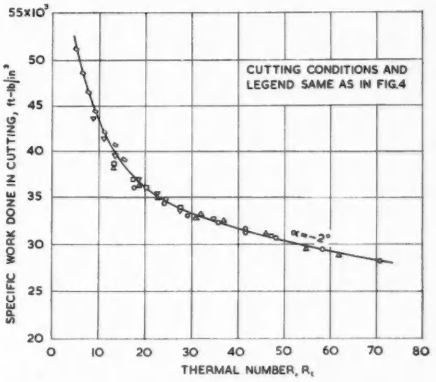

Fig. 6. **Relationship between specific energy expended in metal removal and thermal number.**

From the standpoint of specific energy requirements and rate of metal removal, a high thermal number is desirable. However, the effect of an increase in speed and/or feed on the tool—chip interface temperature must also be considered, as this is an important factor in the life of the tool. It has been found that the life of a high-speed steel tool varies approximately inversely as the 20th power of the tool—chip interface temperature. While it is likely that the exponent is lower for carbide tools than for high-speed steel tools, relatively small changes in interface temperature will still have a profound effect on tool life.

An increase in speed and/or feed (in the usual range) increases the tool—chip interface temperature and, as a consequence, reduces the ability of the tool to withstand the abrasive action of the chip, thus shortening tool life. As the opposite trend is observed in specific energy requirements, these opposing factors indicate an optimum combination of feed and speed for the most economical removal of metal.

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The Influence of Sound and Ultrasound on Electro-Chemical Processes

By A. ROLL. (From *Metalloberfläche*, Vol. 4, Nos. 4, 5 and 6, 1952, pp. B49-53, B65-70, and 81-89 respectively, 26 illustrations.)

(*Continued from August issue*)

The independence of the ultrasound potential of the pH-value of the solution cannot be so simply explained, but the values below the reversible equilibrium potential are easily understood by considering that the gas is separated at a pressure lower than the external pressure (on which the calculation of the equilibrium potential is based), owing to the suction effect of the cavitation voids.

The above considerations are valid for very intense sound. The curves indicate, however, that a depolarisation takes place already at lower intensities, at which there is no, or only very little, cavitation. At these lower intensities the ultrasound action is analogous to mechanical stirring of the electrolyte at the cathode.

The author himself has further investigated this stirring effect[9]. It was assumed that small gas bubbles, such as are formed during electrolysis, exist in the liquid which is subject to an ultrasonic field of moderate intensity, causing no cavitation.

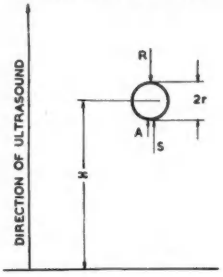

Fig. 7. **Forces acting on a bubble in an ultrasonic field.**

In this field, three forces act on the bubble (Fig. 7): the buoyancy A, the opposing friction R and the sound radiation pressure force S along the direction of sound propagation. Assuming that A and S are parallel, we have the equation of motion of the bubble:

$$m\frac{d^2x}{dt^2} = S + A - R \qquad .. \qquad (9)$$

Before drawing any conclusions from this equation, the assumptions, in particular the introduction of the radiation pressure, must be investigated. A glycerin-water mixture was used for the experiments, the high viscosity of which slows down the movement of the bubbles, and in which they are fairly stable. The mixture was stirred for about two minutes, thus forming a stable air-emulsion. The average velocity of ascent of the air bubbles was less than 1 mm/sec. The emulsion was then placed in a glass tube, and exposed to an ultrasonic field of 1-2 watt/cm² intensity and 284 kcs frequency parallel to its length. It was observed that at first the air bubbles were driven rapidly and irregularly upwards, but after a short time a sharp boundary was formed between air-free and air-rich liquid. This boundary moved steadily upwards with a velocity of 1 to 2 cm/sec, getting gradually slower. The larger bubbles, which are more buoyant, initially rose faster than the small ones. However, the small bubbles remaining behind were then exposed to a greater sound pressure and so gradually caught up with the larger ones. In this way an equilibrium condition was established and the boundary formed.

The boundary thus consists of the smallest bubbles occurring in the mixture. It is nearly homogeneous and therefore a very suitable model for the measurement of the motion of gas bubbles in an ultrasonic field.

As in preliminary experiments the buoyancy A was found to be small in comparison with the radiation pressure force S, it can be neglected in eq. (9), and since only the steady state without acceleration is of interest, the equation of motion reduces to

$$S - R = 0 \qquad .. \qquad .. \qquad (10)$$

By Stokes' Law $R = 6\pi r\eta v$

where r = radius of bubble, η = viscosity of liquid and v = velocity of bubble. If the radiation pressure is denoted by p, then $S = \pi p r^2$.

The radiation pressure, which is proportional to the sound intensity, falls off exponentially owing to absorption. At a height x it is

$$p_x = p_0 e^{-\alpha x}$$

where α = absorption coefficient. Substituting in eq. (10) and integrating, we get

$$t = C(e^{\alpha x} - 1) \qquad .. \qquad .. \qquad (11)$$

where $C = 6\eta/r p_0 \alpha$.

Fig. 8 shows the measured and calculated values, using appropriate values of the constants C and α. The agreement is very satisfactory, and the value of α also agrees with that found in the literature. The constant C gives a bubble diameter of 0·12 mm, which could not be checked, but which appears to be reasonable. We thus have the required experimental justification for the assumptions made in eq. (9), from which further conclusions can now be drawn.

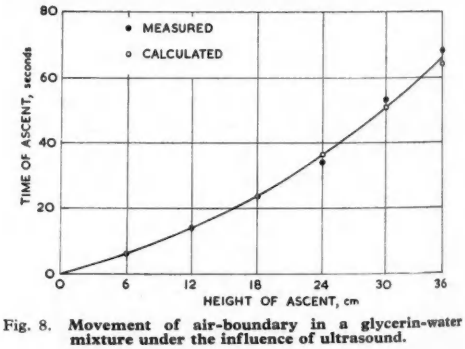

Fig. 8. **Movement of air-boundary in a glycerin-water mixture under the influence of ultrasound.**

For gas bubbles appearing during electrolysis, eq. (9) cannot be simplified as for the glycerin-water mixture. The velocity of rise of the bubbles is no longer negligible, and Stokes' Law contains the relative velocity of the bubbles and the liquid, which it is difficult to establish, as the electrolyte is not stationary, some of it being dragged along with the bubbles. Volumes of liquid containing a large number of bubbles will experience an upward force. It will be assumed that the upward velocity of the liquid is proportional by a factor k to the bubble velocity v. The equation of motion will now be:

$$m\frac{d^2x}{dt^2} = \frac{4}{3}\pi r^3(s_L - s_G) + p\pi r^2 - b\pi r\eta(1-k)v \qquad (12)$$

In this equation the upward force and the radiation

pressure force is taken as constant, since we are only interested in occurrences near the cathode, and in this narrow region the absorption may be neglected. After integration between appropriate limits, neglecting the inertia term and the specific gravity s_G of a gas bubble in comparison with s_L, the specific gravity of the liquid, we obtain for the upward velocity :

$$v = \frac{1}{18\eta}\left(4 s_L + \frac{3p}{r}\right)\frac{r^2}{1-k} \quad .. \quad (13)$$

Fig. 9 gives the results of this equation graphically, for two different sound intensities, assuming a drag coefficient $k = 0{\cdot}2$.

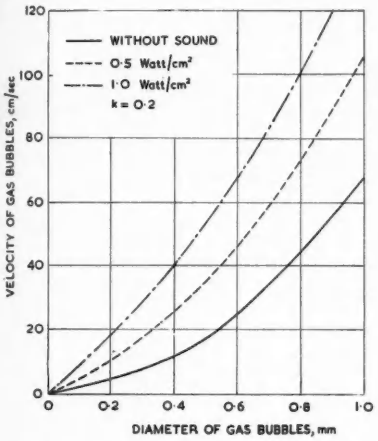

Fig. 9. **Velocity of rise of gas bubbles as a function of bubble diameter.**

As Fig. 9 indicates, the upward velocity of gas bubbles and, hence, the flow velocity are considerably increased by ultrasound. Mechanical stirring generally gives a greater flow velocity than can be expected with rising bubbles. It must be borne in mind, however, that for a laminar flow past a fixed plate—in this case the cathode—the velocity decreases with the distance from the surface, and is practically zero in the boundary layer. The concentration exchange in the boundary layer, where the discharge of the ions takes place, is not therefore speeded up to the extent to which the flow velocity is increased by stirring. In contrast, the effectiveness of ultrasound in this respect is independent of the distance from the cathode, affecting the boundary layers equally.

In the absence of a mathematical expression for "stirring" it is not possible to arrive at more exact conclusions, but it can be said with certainty that the ultrasound always exhibits a stirring effect when gas bubbles are present in the liquid.

This stirring effect is especially marked when, in addition to gas evolution, a metal is deposited. Experiments by the author on nickel electrolytes of comparatively low concentration are described. A low ultrasound intensity of 0·3 watt/cm² was used, at which cavitation would certainly not occur. Fig. 10 shows that, for all electrolytes, the current efficiency with respect to nickel in a stationary bath falls off very soon in favour of hydrogen evolution. Owing to the low metal ion concentration, the deposition potential, even at low current densities, shifts so that only hydrogen is evolved. Electrolysis in an ultrasound field shows a falling off of nickel deposition at a much later stage. The improvement of metal ions in the boundary layer takes place at much higher current densities owing to the stirring effect of the sound. A similar, though lower, increase in current efficiency is brought about by mechanical stirring.

Summing up this section, it can be stated that ultrasound has an effect on the electrolytic evolution of gases. At high intensities, the suction effect of the voids actively participates in the work of evolution. At lower intensities there is a stirring effect, the result of the radiation pressure acting on the gas bubbles present. During the electrodeposition of metals the effect manifests itself by delaying the impoverishment in metal ions of the electrolyte boundary layer and thus increasing the metal yield at higher current densities.

D. The Effect of Ultrasound on the Electrodeposition of Metals.

Experiments in this field have been carried out by applying a sound or ultrasound frequency to the cathode itself, or by irradiating the electrolyte with an ultrasound beam either parallel or normal to the cathode. Different results are to be expected in each case.

Fr. Müller and H. Kuss experimented with an oscillating cathode.[10] A circular plate was fixed to the emitting surface of a magnetostriction oscillator, and served as a cathode. In another series of experiments, a cylindrical cathode was similarly fixed, the oscillations in this case being parallel to the cathode surface. The anode surface was parallel to the cathode. Amplitudes of 30-40 mm were reached. In all experiments the electrolyte was kept in circulation at a controlled speed.

The object of the tests was to investigate the influence of the cathode movement during deposition on the quality of the surface. To facilitate the removal of the deposited layer for hardness measurements, the cathode was first coated with a silver iodide film containing some copper. The majority of the experiments was carried out on copper, nickel, chromium and brass, with the cathode vibrating at right angles to its surface.

Electrolytic deposition of copper from a copper sulphate bath at the high current density of 1400 mA/cm² gave a much finer and better adhering deposit when subjected to ultrasound influence. From very dilute copper sulphate solutions with only 0·03 per cent copper content and at current densities of 60-100

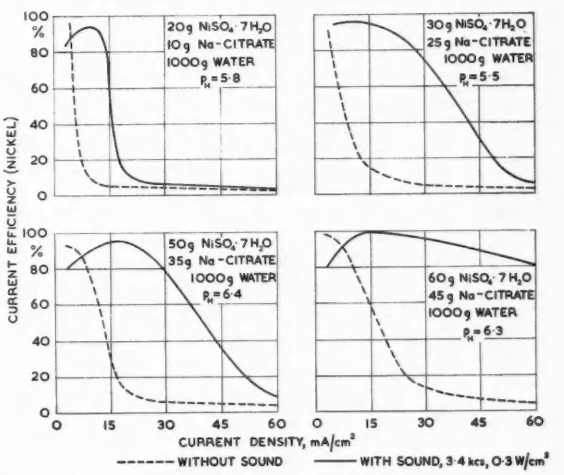

Fig. 10. **Increase of current efficiency in different electrolytes owing to stirring effect of ultrasound.**

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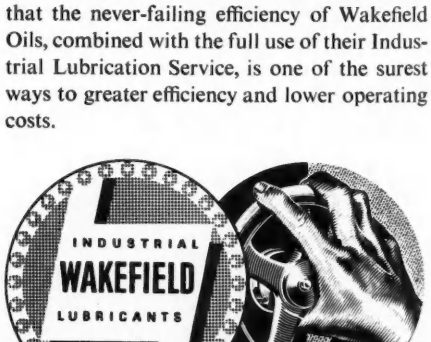

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mA/cm² a firm deposit can still be obtained, while without ultrasound no deposit or a very loose deposit is formed. Hardness measurements show an increase of 40 per cent on average when sound treatment is applied. The tensile strength of the deposited copper foil is also increased, as Fig. 11 shows.

Nickel deposited on the oscillating cathode also shows a considerable improvement in structure. The surface is shiny and shows no bulbous excrescences along the edges. Hardness and tensile strength are improved and porosity is reduced. Chromium gives similar results, the hardness increasing considerably with ultrasound (Fig. 12).

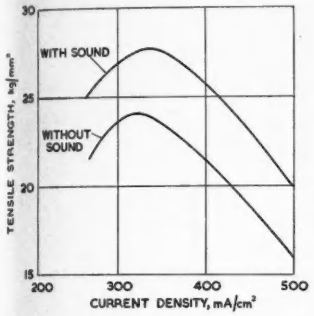

Fig. 11. **Tensile strength of copper deposits.**

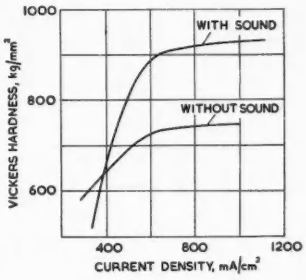

Fig. 12. **Hardness of chromium deposits.**

In brass deposition, the ultrasound increases the current efficiency and the zinc content. The anodic oxidation of aluminium is delayed by ultrasound, resulting in a better surface formation.

These effects are very much smaller for a cathode oscillating parallel to its surface. It was nevertheless possible to deposit gold from a very dilute solution of 0·05 mg/litre at a current density as high as 20 mA/cm².

The above experiments indicate a definite improvement in the mechanical qualities of the deposited layer on a cathode oscillating with ultrasonic frequencies. Other work,[2] however, suggests that cavitation often occurs at the cathode, which attacks the deposit. It must be assumed that in the experiments discussed the ultrasonic output was not high enough to cause appreciable cavitation.

Experiments with higher-frequency sound were also carried out by various workers,[11,10] the sound in this case being applied to the liquid. In one arrangement, a piezoelectric oscillator of 400 kcs frequency was used. The cathode was placed above the quartz oscillator and below the anode. The ultrasound, applied to the electrolyte through an oil bath, excites the cathode to oscillation normal to its surface. The apparatus was used for the dispersion of metals and for emulsification.

The most suitable materials for the cathode are those which are difficult to plate, such as tantalum or aluminium.

If a metal is now deposited on the cathode, it is thrown off again owing to its weak adherence and is finely dispersed in the electrolyte. According to experimental conditions, the metal either settles at the bottom of the vessel or forms an emulsion.

Through altering the cathode surface, the intensity, the concentration of the electrolyte and the current density, the size of the particles can be varied within wide limits. Practically all metals which can be electrolytically separated can also be dispersed in this way. Various constructions suitable for technical use are also described in reference 11.

An essentially similar arrangement was used to investigate the electrodeposition of copper, nickel and chromium. The improvement in structure, hardness and strength was in this case less than that for the directly excited cathode. This is attributable to the lower sound intensity which results from absorption in the electrolyte and at the walls of the vessel.

An arrangement which employs an ultrasound beam through the electrolyte and parallel to the cathode was used by the author in his investigations on the electrodeposition of nickel.[12] The circular cathode consisted of two parts, an inner measuring cathode of 1 cm² surface area, and a surrounding cylindrical auxiliary cathode of 9 cm² area, separated from the inner one by an insulating ring. With this arrangement, the measuring cathode can easily be removed and the current is equally distributed over the surface. The cathode was hung vertically in a beaker containing the electrolyte. The beaker was placed immediately above a magnetostriction oscillator arranged to radiate upwards. Oscillator and beaker were immersed in water. The nickel anode, suspended parallel to the cathode, was outside the sound field. The maximum sound intensity at the cathode was 0·3 watt/cm² at 34 kcs. No cavitation took place at this intensity. The ultrasound field in this arrangement extends as far as the cathode surface. Irradiation of the electrolyte alone showed no effects. The electrolyte had the following composition: 40g nickel sulphate, 35g neutral sodium citrate, 1 litre water, pH value about 6. Current density was 2·7 mA/cm². On a polished surface a bright nickel deposit was obtained. In all experiments, about 4 mg was deposited, corresponding to a layer about 4μ thick. The cathode deposition potential was measured by means of a contact point on the cathode against a saturated potassium chloride—calomel electrode.

(*To be continued*)

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SOVIET MACHINE TOOLS

(*Continued from page* 310)

difficult to see any remarkable advances compared with similar production lines in motor car and other mass production factories in the U.S.A. and elsewhere. Clearly, these spectacular robot installations have not always fulfilled all expectations, and today, what distinguishes discussions among Russian engineers is their familiarity with the limitations of these show-pieces and their appreciation of the importance of comprehensive planning to ensure the success of fully automatic installations. The limitations upon components suitable for fully automatic manufacture are well known, but Russian research institutions have published very valuable work on the principles of statistical mathematics which govern such projects. This research includes many thousands of observations in search of the statistics of failures under operating conditions.

(*To be continued in our next issue*)

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AERODYNAMICS

Two-Dimensional Losses in Turbine Blades

By C. A. MACGREGOR. (From *Journal of the Aeronautical Sciences, U.S.A.*, Vol. 19, No. 6, June, 1952, pp. 404-408, 7 illustrations.)

TESTS have been made on three typical turbine blades in a two-dimensional cascade tunnel. The tests were run at varying angles of attack, stagger angle, solidity, and downstream survey stations at a Mach Number of about 0·4 and a Reynolds Number of $6{\cdot}5 \times 10^5$. The static pressure distribution about the blade was measured by 27 static pressure taps. The wake behind the blade row was surveyed and the loss determined.

Calculations were made of the boundary-layer loss at the various angles of attack, stagger angle, and solidity using the measured pressure distribution. The calculated loss was found to agree with the measured loss even though the pressure distribution varied greatly. It was found that the loss on the suction side of the blade was about six times as large as the loss on the pressure side. This was the result of the shape of the pressure distribution about the blade.

Discharge measurements made behind the blade row showed that the wake spread out as it moved downstream. The loss did not increase greatly in the first half-chord length behind the blade row, even though the shape parameter did.

FOUNDRY PRACTICE

Correlation Between Analysis and Certain Mechanical Properties in Ordinary Grey Cast Iron

By J. DRACHMANN. (From *Gjuteriet, Sweden*, Vol. 42, No. 7, July, 1952, pp. 108-114, 15 illustrations.)

THIS investigation was undertaken to show that it is possible to obtain results of a certain scientific and practical value without expensive instruments and laboratory equipment, by using daily test results which are treated statistically. As an example, the author has chosen the influence of carbon, silicon, manganese and sulphur on machinability, Brinell hardness and chill depth, in ordinary grey cast iron with a phosphorus content of approximately 0·60 per cent. The author has used both linear and quadratic approximations. The results show that variations of machinability and Brinell hardness with the carbon and silicon content of the iron are equally well described as variations of said properties with the carbon equivalent. For machinability this is true at least by linear approximation. The chill depth, on the other hand, has a minimum at 2·70 per cent Si. The manganese-sulphur ratio has a great influence on machinability. It cannot be statistically combined with C and Si in one equation and, therefore, it is treated separately. The author ends by regretting that so few foundrymen are interested in statistical research, because the benefit from many valuable test results is thus lost.

GLASS

Dielectric Losses in Glass

By J. M. STEVELS. (From *Philips Technical Review, Holland*, Vol. 13, No. 12, June, 1952, pp. 360-370, 14 illustrations.)

THE dielectric losses in glass arise from three causes: conduction, after-effect and resonance. The various forms of losses are described, it being shown that the conduction losses are of importance only at very low frequencies and high temperatures. The after-effect losses can be divided into "relaxation losses," occurring at room temperature in the frequency range of 10^{-3} to 10^6 cps and shifting towards higher frequencies as the temperature rises, and "deformation losses" which are approximately proportional to the frequency and are of particular importance at low temperatures. The resonance or vibration losses occur mainly at high frequencies (10^{10} to 10^{13} cps) and, as the temperature rises, probably shift towards lower frequencies. The influence of the chemical composition and the structure of the glass upon the various losses is investigated, special attention being paid to the borate glasses, in which an accumulation region and a destruction region are to be distinguished according to the composition. It is indicated how the losses can be reduced in certain frequency ranges, some examples being given. Finally, it is shown how the dielectric losses can be taken as indications of the changes taking place in the structure of a glass when its composition is modified.

METAL CUTTING

The Shear Angle Relationship in Metal Cutting

By M. C. SHAW, N. H. COOK and I. FINNIE. (From Paper No. 52-SA-51 presented at the Semi-Annual meeting of the *American Society of Mechanical Engineers*, June 15-19, 1952, 20 pages, 15 illustrations.)

THE several analytical solutions that have been presented for the shear angle in metal cutting are briefly described and the underlying assumptions critically discussed. The friction process which obtains in cutting is considered in detail, and it is shown that a variable restraint and accompanying variation in the effective hardness of the metal cut constitutes a major difference between ordinary friction and that between chip and tool. This variation in relative restraint and effective hardness accounts for the wide variation in the coefficient of friction with rake angle observed in metal cutting. Furthermore, this variable restraint constitutes a significant link between shear and friction processes, and is responsible for the shear plane not being in the direction of maximum shear stress in the general case. These new concepts are incorporated with the best features of previous work, and an equation is presented, in which the angle between the shear plane and direction of maximum shear stress figures prominently. The new equation for shear angle is illustrated and discussed with the aid of experimental cutting data covering a wide range of operating conditions.

STRESS ANALYSIS

Thermal Stress in Power-Producing Elements

By A. S. THOMPSON. (From *Journal of the Aeronautical Sciences, U.S.A.*, Vol. 19, No. 7, July, 1952, pp. 476-480, 2 illustrations.)

THIS paper considers the stresses in a material resulting from the flow of power through it, when the density of power generated has a given distribution. From Hooke's law relating elastic stresses and strains, a general expression is derived for the order of magnitude of the thermal stress produced by a temperature dif-

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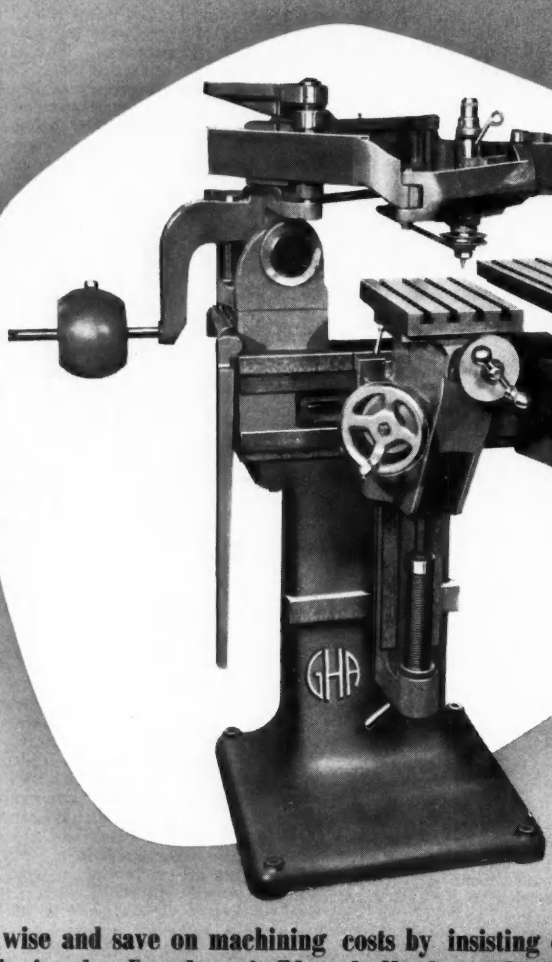

The picture shown above is a No. 2. three-dimensional Diesinking Machine, designed by the world-renowned organization — George H. Alexander Machinery Limited, and built by a subsidiary, Messrs. Precision Grinding Limited.

Be wise and save on machining costs by insisting on castings made in the Foundry of Edward Matthews Limited where "Quality is the Keynote"

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ference in the material. The special case is studied of the stress in a heated cylindrical tube with a given distribution of power density and with heat flow through its inner surface. The stress in this cylindrical tube resulting from a power distribution in the form of a step function of the radius is determined.

It is shown that the expression for the maximum stress in the heated tube depends on three groupings of parameters—the first involving the properties of the heated material; the second, the average power density generated; and the third, geometry considerations. From these groupings of parameters, the following conclusions are drawn: (1) A material should be used having low values of the modulus of elasticity and the coefficient of thermal expansion and a high value of thermal conductivity; and (2) from geometry considerations the tubes should be of small diameter and the power should be generated in a thin layer of material directly at the cooled surface.

These thermal stresses are of importance, since in extreme cases they are the cause of spalling (surface failure).

S.B.A.C. FLYING DISPLAY AND EXHIBITION

(*Concluded from page* 289)

result of this firm's turbo-prop engine development. Finally, in the turbine range, the great "Olympus" opens a new stage in jet propulsion. Bristol designers have now achieved not only a single unit approaching already 10,000 lb thrust, but also a level of efficiency not hitherto attained. This efficiency has been made possible by a large increase in pressure ratio rather than high gas temperature. Two rocket motors were exhibited this year, the A.S. Snarler for bursts of speed at high altitude and the D.H. Sprite for assistance at take-off.

The incredible range of endeavour which goes into the construction, equipment and operation of aircraft was again impressed upon the onlooker making his way through the 200-odd exhibition stands. Space does not permit us even to mention every new creation beyond aircraft and engines, and it would be unwise to justify the selection which follows except by the reviewer's personal interest and taste.

Among airscrews we perceive the first hollow steel blade made in this country by de Havilland. The "new look" of broad thin tips to suit turbine needs is increasingly prominent. Undercarriages of the bogie type as exhibited by Dowty and Electrohydraulics are spreading. Goodyear Tyre & Rubber Co. display the crosswind landing gear. Wheel brake designs are continually refined by Palmer (pneumatic), Dunlop (automatic), and Girling (hydraulic).

All authorities agree that in military and civil aviation alike, the most pressing need of the hour is for advancement in traffic control and navigation. No spectacular new principles have appeared this year, but the low cloud base during part of the display week gave an opportunity to prove that equipment actually in use at Farnborough aerodrome is of a very advanced type. The precision with which the high-speed aircraft broke cloud exactly over the runway was remarkable. The Decca flight log continues its progress towards ever-increasing automaticity and simplification of position indication. A passenger flight log is under development.

Better instruments for indication of flight information and control of flight are again in evidence. There are numerous advances in almost every type of instrument, with emphasis on high speed (Mach meters) and high altitudes (altimeters). Sperry and other companies now offer artificial horizons with complete freedom in roll. Smith's Aircraft Instruments have incorporated altitude control in their all-electric SEP 2 auto-pilot and have also reduced its weight. Salford Electrical Instruments exhibit a very accurate radio altimeter and a radio sonde. Kelvin & Hughes show a Mach switch among their new devices.

Auxiliary power sources for aircraft retain their diversity, and improvements are seen in all systems. In fact, exhibits on the Dunlop and Hymatic stands support the impression that high-pressure (3000 psi) pneumatics are returning to favour. Hydraulic pressures are going up and a Dowty pump reaching 4000 psi is shown. A remarkable development in "electrics" is the silver-zinc lightweight accumulator by Venner Ltd., which has moved further towards airworthiness. Control assister units embodying all the desirable features of duplication and "feel" are exhibited by most equipment constructors.

Immense ingenuity is displayed by the designers of various essential aircraft services, such as air conditioning, pressurization and de-icing, to ensure safe automatic control. Normalair, Teddington Controls, and other firms, show convincing replica models of their inventive skill. Electrical and thermal de-icing are further pursued by Dunlop and Lucas. Refinements are seen in fuel systems and fire prevention.

Materials are usually characterised by gradual improvements. This year, pure titanium and pure zirconium make their debut on the Accles & Pollock stand. Magnesium castings now have thorium added for better heat resistance.

Exhibitors of research equipment, among whom the Ministry of Supply is prominent, include every well-known firm in the field. The wealth of information offered defies brief selection.

INTERNATIONAL MACHINE TOOL EXHIBITION—LONDON, 1952

(*Concluded from page* 323)

surface finish measuring instrument, manufactured by **Taylor, Taylor & Hobson Ltd.,** of Leicester. The attachment extends the field of application of the instrument. It enables the hitherto almost impossible measurement of the surface finish of concave or convex surfaces of small components and the measurement of chatter or vibration waves, and so removes severe limitations on the use of the instrument. The principle of the attachment is the provision of a datum quite independent of the measured surface, so that the standard diamond stylus can be guided in any path in the

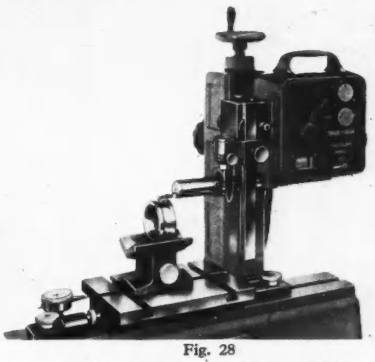


Fig. 28

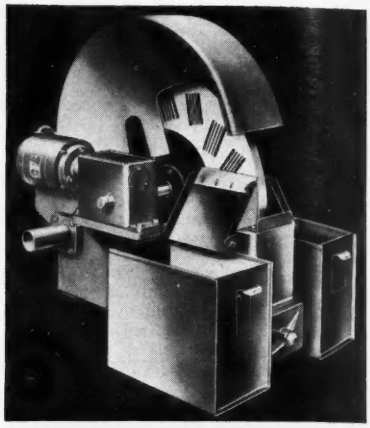
form of a straight line or true radius. This means that the surfaces of ball race tracks, gear teeth and other components having curved surfaces can be measured. Furthermore, small components which until now could not be measured owing to the necessary distance between skid and stylus on the standard pick-up can now be dealt with, using an auxiliary datum surface. The attachment itself consists of several fittings specifically designed for the various applications mentioned above, but some of its components are common to all applications. The illustration, Fig. 28, shows the instrument being used for measuring the surface texture of a ball bearing race.

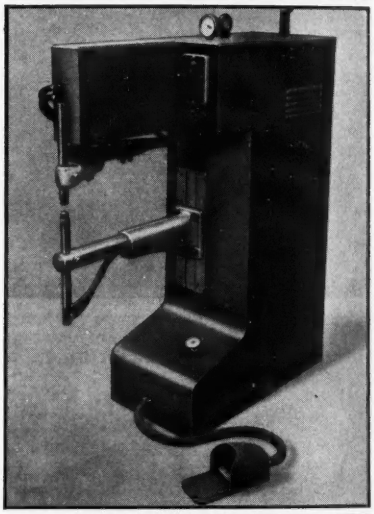
PHILIPS

at the

MACHINE TOOL TRADES EXHIBITION

Sept. 17 — Oct. 4





THE Industrial Group of Philips Electrical Ltd. take pleasure in announcing that they will be participating in the above exhibition, and will show a considerable range of their various industrial equipments.

PHILIPS MAGNETIC CLARIFIERS

Of great interest at the Exhibition is the new version of Philips Magnetic Clarifier. This equipment will be exhibited attached to grinding, honing and similar machines at their maker's own stands — as well as on the Philips stand. Also on view will be Line Type Filters, Magnetic Plugs, Wire Wound Strainers and Combined Filters.

PHILIPS RESISTANCE WELDING

Three new Resistance Welding equipments—in addition to existing equipment — will be on exhibition, and will be demonstrated.

PHILIPS ARC WELDING

Apart from the existing Type E.1381/1 Welding Transformers, two new equipments — one of which is an oil-cooled transformer — will be on view.

PHILIPS H.F. GENERATORS

The Philips F.18 (10KW) Induction Valve Driven Generator will be seen in operation on the stand.

PHILIPS MEASURING INSTRUMENTS

Two particularly interesting instruments will be featured. These are the Type PR9150 Electronic Roughness Tester and the Type GM5536/37 Electronic Micrometer.

PHILIPS RECTIFIERS

A special working model in a transparent plastic shell will be included among the exhibits.

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International Machine Tool Exhibition—London, 1952

The August issue of " The Engineers Digest " contained a description of a number of interesting exhibits at the International Machine Tool Exhibition at Olympia, London, organised by the Machine Tool Trades Association. The exhibition opened on September 17th and will continue until October 4th. Due to the very large number of exhibits and their random distribution among individual makers' stands, it is impossible at this stage to present a comprehensive survey or to trace any prominent general trends in machine tool development. A random selection of interesting and new machines has therefore been described, and a further selection is dealt with in this issue. It is intended to give an appreciation of the Exhibition in retrospect in a future issue.

One of the more recent grinding machines to be shown is the Model " OW " 4 × 12 in. fully automatic plain grinding machine, using the " Fulcro-sizer " principle. It is one of the wide range to be exhibited by the **Churchill Machine Tool Company,** Manchester, and is illustrated in Fig. 15. The machine is intended

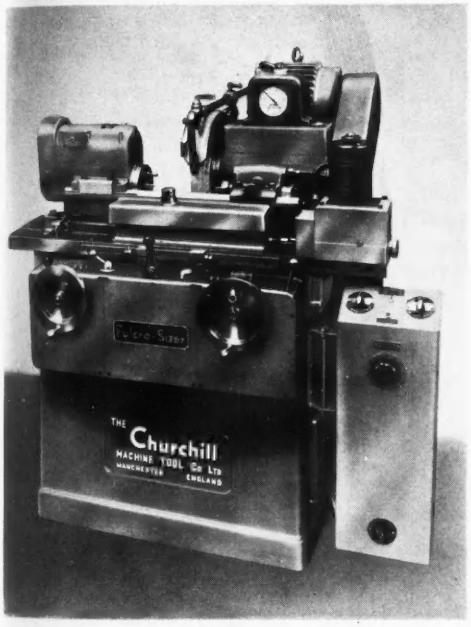


Fig. 15

mainly for the grinding of small parts to great accuracy and should be of interest to the light precision engineering industry. The " Fulcro-sizer " principle operates a fully automatic cycle with the work being fed towards the wheel by a tilting table instead of the normal wheel motion towards the work. It is claimed that the system provides much greater final sizing accuracy, and fully automatic sizing to ±0·00005 in., over large batches of components, is possible. A recent useful refinement is the provision of a motor-driven metering pump, which maintains constant cycle times despite variations of temperature and viscosity of the hydraulic oil. This difficulty, which has now been overcome, is one often experienced with hydraulically controlled machine tools. The time cycle is indicated on a dial fitted to the machine. Once the initial setting has been completed, the dial may be locked, and any changes in cycle times are prevented. Although the maximum grinding capacity is only 4 in. diameter, a 14 in.-diameter grinding wheel is used. This large wheel size has advantages in lower radial wheel wear, and consequently higher accuracy over longer working periods. The wheelhead has a 3-hp motor running at 1440 rpm, whereas a ½-hp stator-rotor unit is built into the workhead casting. A three-speed cone pulley drive provides workhead speeds of 294, 591 and 898 rpm. A similar-size machine, designed as a non-automatic plain cylindrical grinder, is also being built, and these machines constitute the smallest cylindrical grinders ever built by this maker.

An interesting machine for the rapid and accurate production of pierced holes in flat sheets and light plates is shown by the distributors, **Dowding & Doll Ltd.,** London. It is the Wiedemann Turret Punch Press, Model RA-4IP, manufactured by the Wiedemann Machine Company of Philadelphia, U.S.A. The accuracy is obtained by using templates of hole lay-outs and the rapidity is achieved by turret mounting of punches and dies. The operation of the machine, shown in Fig. 16,

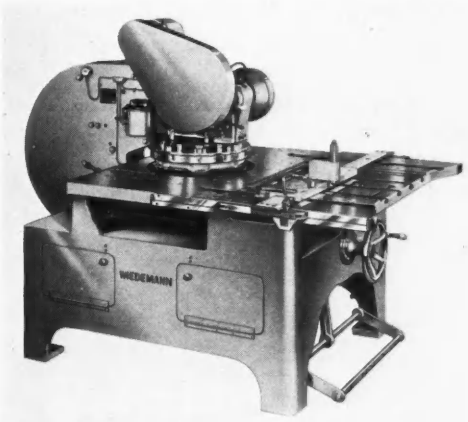


Fig. 16

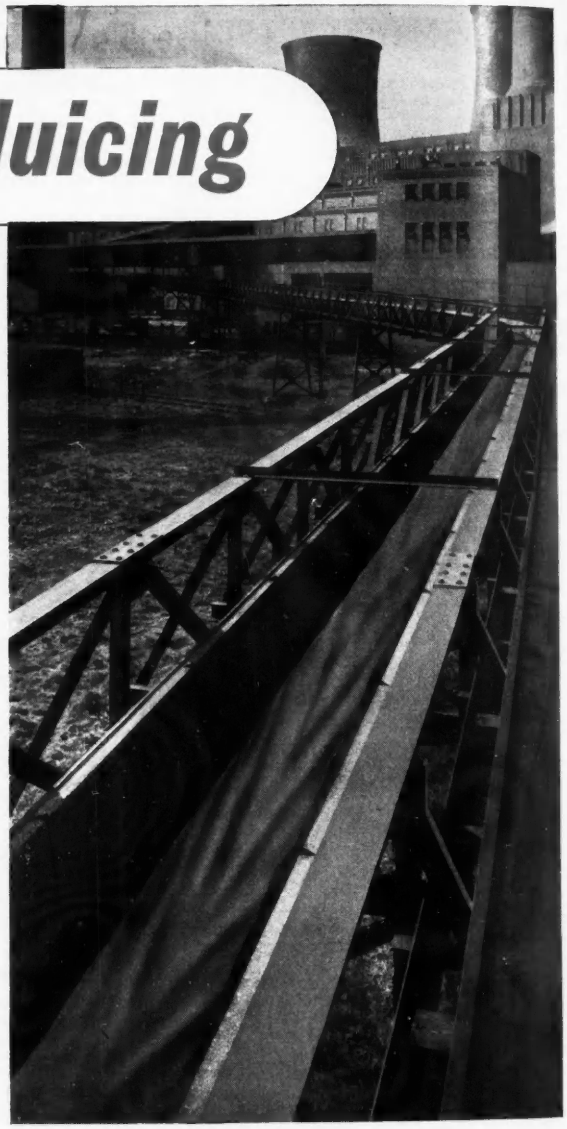
is briefly as follows: The work and template are mounted on the table and locked. The template has ¼ in. diameter holes, accurately located to correspond with the centres of round or shaped holes to be punched in the work. A stylus on a pantograph device is moved by the operator to engage in the template holes. This movement simultaneously causes the work to move in direct relationship, so placing it in the correct position under the punch. All holes to be produced by the same punch can be clearly marked so that they can be pierced in rapid succession. The punches and dies can be correspondingly marked. The turrets are rotated by a handwheel conveniently positioned for the operator; their movements are synchronised and they are locked in position by pins engaging in bushes. A treadle is used for engaging and releasing the pins. Positive punch and die alignment is ensured as the press will not trip unless the turret locking pins are fully engaged. Furthermore, the press will only trip after the operator has depressed the stylus point in the template hole. The machine is particularly suitable for shorter runs, or for the type of work where changes in hole lay-out are likely. Holes up to 3 in. in diameter in 14-gauge steel

Gravity sluicing

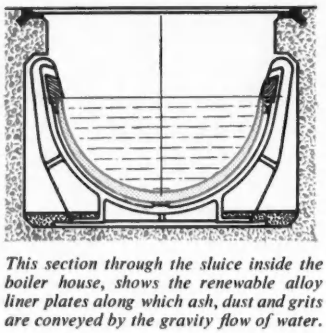
removes
ASH...DUST...GRITS

Gravity sluicing is an extremely simple and efficient system of removing ash, dust and grits from stoker-fired or pulverised fuel-fired boiler plant. Operating and maintenance costs are low, and there are few working parts in contact with the materials conveyed.

The system is readily adaptable to any site conditions and layout of boilers. Combustion chamber ash, dust and grits may be discharged directly into a sluice and conveyed by the gravity flow of water to a sump or swirl pit.



This installation at a large Power Station has for more than 10 years handled ash, dust and grits from twelve ICL 320,000 lbs./hr. pulverised fuel-fired boilers, at the rate of 500 tons per day. The mixture is conveyed by gravity sluices to a swirl pit and thence to the disposal ground by means of the gravity flow launder shown in the foreground.



This section through the sluice inside the boiler house, shows the renewable alloy liner plates along which ash, dust and grits are conveyed by the gravity flow of water.

INTERNATIONAL COMBUSTION LIMITED

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heet and up to 2 in. diameter in $\frac{1}{8}$ in. plate can be pierced. The maximum size of sheet which can be accommodated is 24 in. × 24 in.; there are up to 20 turret stations, and the stroke of the ram is $1\frac{1}{16}$ in., there being up to 175 strokes per minute. The performance figures quoted by the makers are very impressive. For example, 81 openings in a receiver chassis made of 0·047 in. thick cold-rolled steel to a tolerance of + 0·005 in. can be produced in 2·65 minutes using 16 punches. Template production time in this case is given as $3\frac{1}{2}$ hours and setting-up time as 48 minutes.

An interesting and unusual machine is the Moore Die Flipper, an American product, marketed in England by **Catmur Machine Tool Corporation Ltd.,** London. It "mechanizes" the handling of dies during try-out and assembly, and die sets of up to 20 in. by 40 in. can be taken apart and turned over with ease. The machine has a platen on which the die set is mounted, and this platen can be swivelled, lifted and turned over. The machine can be used for testing alignments of punches, producing test pieces in paper or thin metal strip, and by utilising the elevating device, entire parts of the die can be lifted for adjustment or removal. This elevating device is fitted on one end of an arm, which is mounted on a rigid column at the rear of the main base. The other end of the arm has a drilling head, so that the machine can virtually be used as a radial drill of $1\frac{1}{2}$ in. capacity. Consequently, punches can be drilled in position and screw holes can be tapped without having to move the die set to a drilling machine. The machine can also be used as a light tool-room radial drill for straight or angular holes. The drilling spindle speeds are steplessly variable between 200 and 1200 rpm.

A fine boring machine of a novel design intended mainly for the boring of cylinder bores is exhibited by **Drummond-Asquith (Sales) Ltd.** The machine, Type FB-50, is manufactured by Ernst Kraus & Co. of Vienna. The machine has the appearance of an enclosed box as shown in Fig. 17, with the spindles feeding

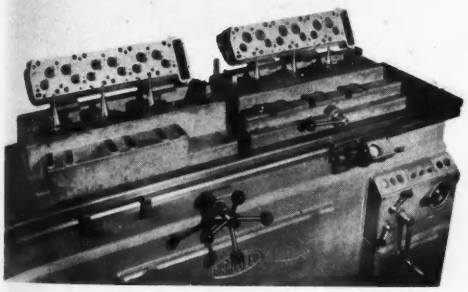


Fig. 17

vertically upwards from within it. This arrangement ensures that the centre of gravity of all rotating parts is very low, thus helping to eliminate vibrations detrimental to the finish of the produced bores. Furthermore, the table surface, which is about 39 in. from the floor, is easily accessible from all sides. The machine is normally equipped with 3 or 6 spindles. Individual spindles can be added or removed with the minimum of alteration to the main drive, and they are accurately adjustable in relation to each other to a minimum distance of $6\frac{1}{2}$ in. A labyrinth, together with the centrifugal action of a disc rotating with the spindle, provide protection against the ingress of swarf, dust and liquids. The maximum boring depth with the largest spindle is 13 in. and the maximum diameter $5\frac{7}{8}$ in. The working surface of the table has a width of about 22 in., with a length varying from 61 to 102 in. The spindle has 7 speeds for each motor speed and a total of 8 feeds.

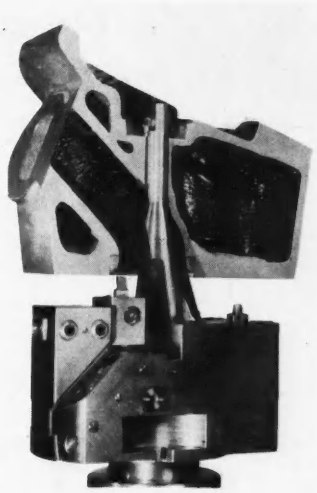


Fig. 18

The particular machine on show will be tooled up for the simultaneous finishing of cylinder head valve guides and seatings, using a combination boring head as shown in Fig. 18.

A new machine exhibited by **Cincinnati Milling Machines Ltd.,** of Birmingham, is the No. 5 "Dual Power" knee and column type horizontal milling machine. As shown in Fig. 19, it is an exceptionally robust machine intended for heavy cuts with carbide-tipped cutters. The full power of the 50 hp motor is delivered to the spindle when it is running at high

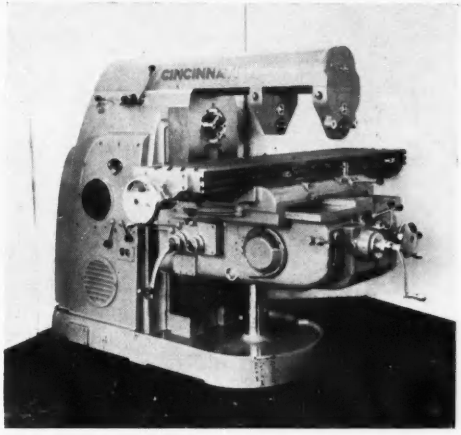
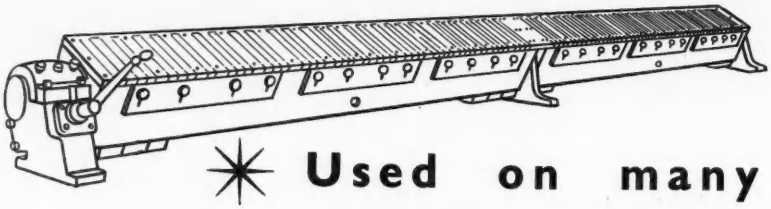
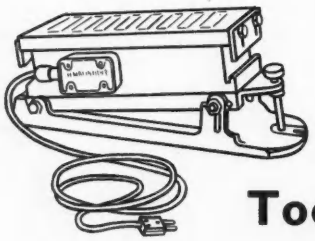


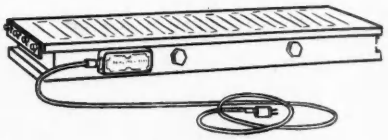
Fig. 19

speeds; the power is automatically reduced by half for the six lowest speeds. The exhibition machine will be set up for slot milling with a carbide-tipped cutter, using the automatic table cycle. The tool and die milling machines by the same maker (Fig. 20) also have several interesting features. They are intended for the economical machining of tools, moulds, and dies involving accurately shaped contours. The machines are exceptionally versatile in that many secondary operations can be performed without resetting. These include drilling, reaming, boring and slotting, and can cover an area of 8 in. by 18 in. The anti-friction leadscrew and



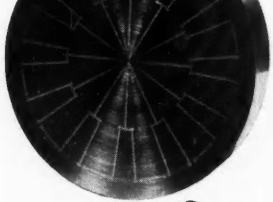
Used on many exhibits throughout the Machine Tool Exhibition of 1952...



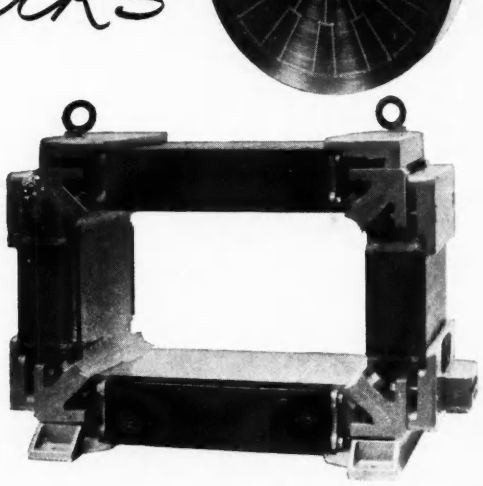


HUMPHREYS

Magnetic Chucks



★ Chucks to meet special requirements, and a standard range of circular chucks from 6″ to 100″ in diameter; Rectangular chucks from 6″ × 3″ to 120″ × 24″; High power chucks for holding nickel-aluminium magnets; Swivel chucks from 10″ × 4″ to 168″ × 12″, for guillotine blades, etc.; Piston ring chucks; Circular chucks with automatic switching for continuous single-pass grinding; and aperture and platen type demagnetizers.



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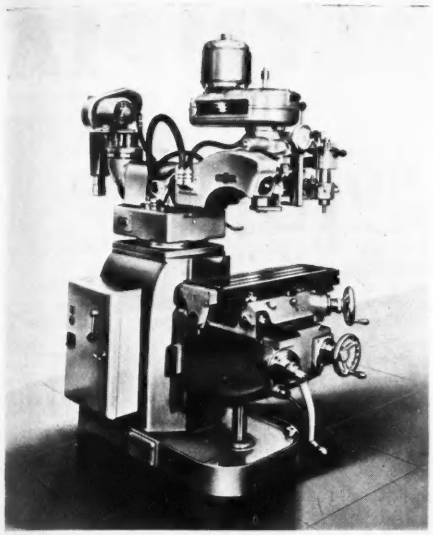

Fig. 20

nut on the saddle and table are of the ball-bearing type, ensuring smooth movements and sensitive control over the cutter action. One of the machines exhibited is set up for reproducing a decorative plaque, using a rotary attachment which carries the master on one table and the work on another. These two tables rotate while the saddle is automatically fed across the knee, resulting in automatic scanning of the circular workpiece.

A new fully automatic spur teeth gear grinding machine is being exhibited by the **Gear Grinding Co. Ltd.**, Birmingham. It is the latest addition to the well-known " Orcutt " range of gear grinding machines and is illustrated in Fig. 21. Its normal maximum capacity is 24 in. diameter and 8 in. length, but it can be adapted to grind gears and pinions between centres with a maximum diameter of 10 in. and a length of 10 in. The machine has an automatic cycle control so that the operator's work is reduced to loading and unloading the components and starting the cycle of operations. The automatic control is electrical and the feeds are provided by cam action at each revolution of the gear. The number of grinding wheel dressings and the stage in the grinding of a gear at which they are to take place are preselected according to the type of work and gear material. A new type of plain bearing

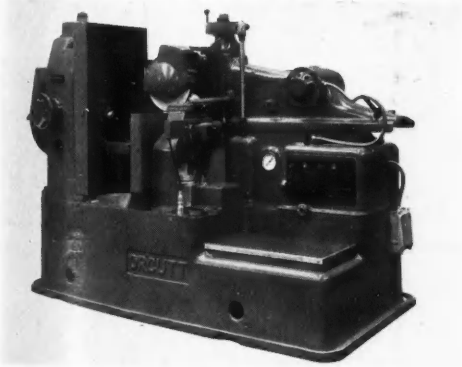

Fig. 21

is used for the wheel spindle and its motor drive, and the makers claim a further improvement in the quality of the work as a result of this modification. Correct machining of the gear prior to hardening, during which a smooth blend is produced between the flank and root form, eliminates the need for slow grinding necessary to clear the root. Higher cam-controlled feeds can then be used for grinding the flanks ; full advantage is thus taken of the preforming, and production times are considerably reduced.

An unprecedented high standard of precision is achieved on the Kearns Optimetric horizontal toolroom boring machine, shown by **H. W. Kearns & Co. Ltd.**, Broadheath, Manchester. The machine shown in Fig. 22 incorporates a patented optical measuring system, applied to the vertical and transverse settings. The system is completely built in, so

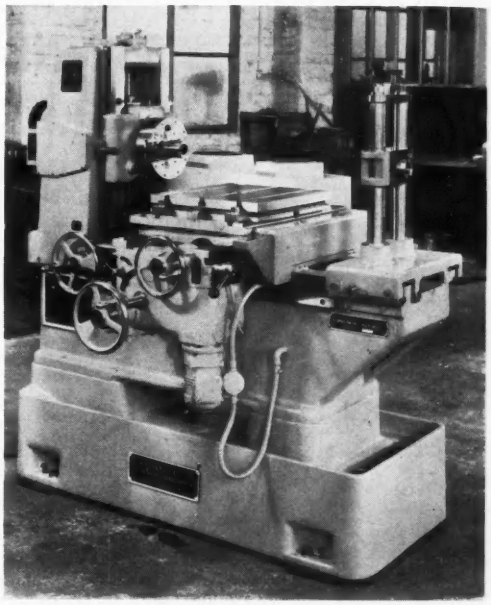

Fig. 22

that no separate end gauges, dial gauges etc. are required. The main advantages of this are the reduction of the possibility of error and a considerable saving in time when setting up. Settings to 0·001 in. with an error of less than 0·00025 in. can be made using the optical system. The rule and vernier settings are projected onto brightly illuminated screens measuring 4 in. × 1½ in., one of which is shown mounted on the table saddle in the centre of the illustration. The size and bright illumination of the screen make it very easy to read, avoiding eye strain normally caused by the constant use of microscopes. The glass scales used on the machine do not wear and are almost indestructible. The machine has several other interesting features and is characterised by the precision for which this well-known maker is known.

A very specialised machine of interesting design is the 72 in. automatic knife grinding machine, exhibited by the makers, **Luke & Spencer Ltd.** of Broadheath. It is intended for the grinding of wood planer, guillotine and scraper knives, and its simplicity and ease of operation make it particularly suitable for the small works. The machine consists of a bed mounted on two cast iron pedestals, and has two accurate ways which are positioned along the upper part of the bed. Within the trough formed by the bed there is a knife

SEE IT AT OLYMPIA

INTERNATIONAL MACHINE TOOL EXHIBITION

ON STAND 101
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THE NEW C-R 24" STROKE SHAPING MACHINE

This high-speed heavy-duty machine, *of entirely new design* is exhibited for the first time. Its features include:—

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holder with a worm reduction gear, so that the holder can be set at any angle to suit the knife being ground. A massive grinding carriage mounted on ball bearing rollers carries a horizontal cup-shaped grinding wheel. The 11 or 12 in. wheel is driven by a 5-hp motor. In operation the carriage traverses to and fro along the ways, being reversed at the end of the travel by means of an automatic reversing mechanism. The cooling of the blade during the grinding process is very important and is provided partly by immersion in the coolant and partly by a high-pressure jet of coolant directed at the blade edge by a special water impeller. This is mounted on the lower end of an extension on the vertical grinding spindle. An interesting feature is the protection of the roller ways by replaceable hardened steel strips held under tension. These can easily be replaced and the original accuracy of the ways themselves can be maintained almost indefinitely. The machine is designed for push button control, but the direction of traverse can also be controlled manually, using a trip bar which actuates a double acting limit switch on the reversing motor.

The M.V.A. production milling machine, built on the unit construction principle and manufactured by **Paul & Co.** of Augsburg, Germany, is exhibited by their agents, **Modern Machine Tools Ltd.,** Coventry. The machine, shown in Fig. 23, demonstrates well the versatility of the unit construction principle. It can be built up with one horizontal spindle, two horizontally opposed spindles, one horizontal and one vertical spindle mounted on the crossbeam, or finally with two horizontally opposed spindles and one vertical spindle. To avoid any possibility of interference between the horizontal and vertical cutters, the vertical head on its unit can be moved up to 3 in. forward or 5 in. back from the plane of the horizontal cutter. The machine is extremely rigid and the table, the working surface of which measures approximately 10 in. by 38 in., has a steplessly variable feed ranging from 0·70 to 14·17 ipm. The speeds of the milling spindles are also steplessly variable; the range is 62 to 1000 rpm, and the power available for each spindle is 2·5 hp. A minor, but

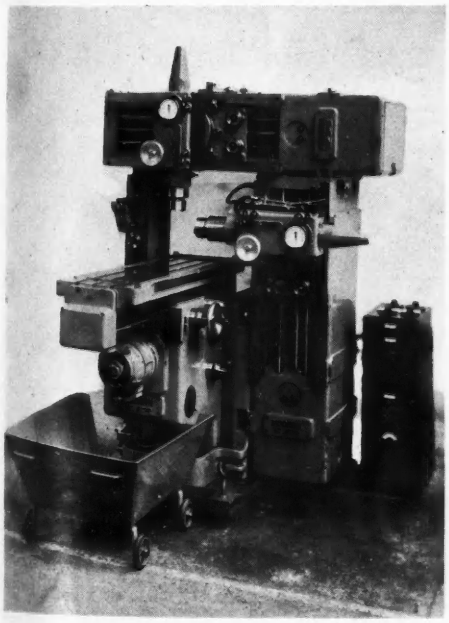


Fig. 23

interesting, point is the mobile coolant tank or sump with a built-in immersion pump. The whole tank is mounted on castors and can be withdrawn from underneath the machine for cleaning out.

The present tendency towards automatic machine tool operation in order to increase output and reduce labour requirements to a minimum is apparent in the 22 in. automatic "Fluifeed" circular cold sawing machine, shown by **Noble and Lund Ltd.,** Gateshead. The machine, illustrated in Fig. 24, is intended for cutting up steel bar stock, and after initial setting up the operation is fully automatic. The machine also stops automatically after sawing off the last piece of a bar. The feed and return of the saw carriage are hydraulically operated, as is also the feeding and clamping of the bar stock. The feeding of the bar is effected by a grip which clamps the bar and a slide which moves it along the exact amount required for cutting off. The timing of the carriage and bar clamping and sliding motions is controlled by tappets, which in turn actuate the control valves. This system ensures that all motions are correctly synchronised and renders the machine foolproof. A counter can be fitted to the vice; this is

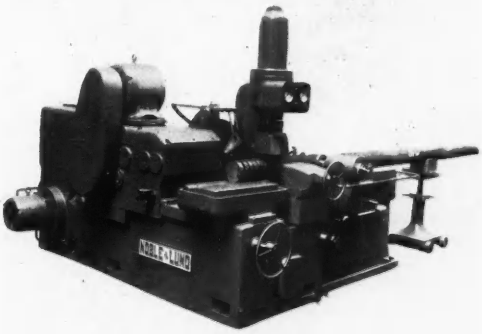
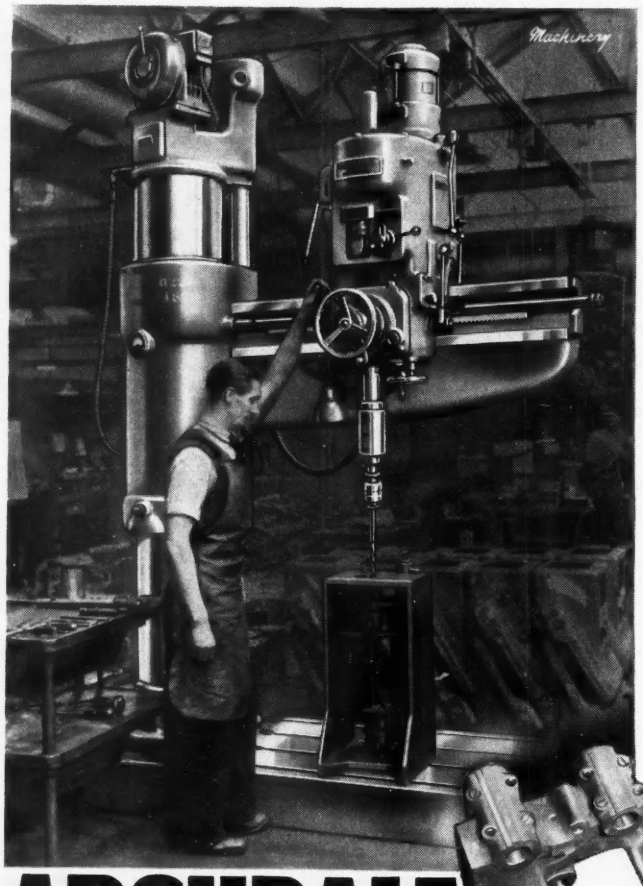


Fig. 24

pre-set to a particular number of cuts. After these are completed, the machine will stop automatically. A spiral chip conveyor is built into an inclined trough in the bed of the machine. The chips are collected there, conveyed to the rear of the machine and deposited in a swarf bin. Another useful feature is the extension of the vertical vice jaw, which grips the bar on both sides of the cut. This prevents the formation of burrs and ensures cleanly finished cut surfaces. The saw spindle can be fitted with an anti-backlash device for sawing tubes or light sections. The maximum sawing capacity is 7¼ in. round bars, and the maximum stroke of the bar slide is 18 in. The 22 in. diameter saw has four speeds from the 10 hp driving motor, the maximum being 91 fpm.

Among the equipment often not considered under the heading of machine tools, there is on show a number of die-casting machines. Several types of the "PECO" range, produced by the **Projectile and Engineering Co. Ltd.,** London, are noticeable among these for their simple and robust design. The Model 5 C, shown in Fig. 25, has a capacity of 4 lb of aluminium and a platen size of 28½ in. × 26½ in. The pressure on the material is 18350 psi with a 1½ in. diameter plunger, and the die locking pressure is 250 tons. The machine is of the cold chamber type, and is therefore suitable for aluminium, magnesium and brass. The injection unit can, however, be replaced by a hot chamber unit, making the machine suitable for zinc, tin or lead. The hydraulic unit and reservoir are built into the base and are easily accessible for servicing. The injection unit, which is mounted on a pedestal



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SIMPLICITY OF CONTROL

HIGH PENETRATION RATES

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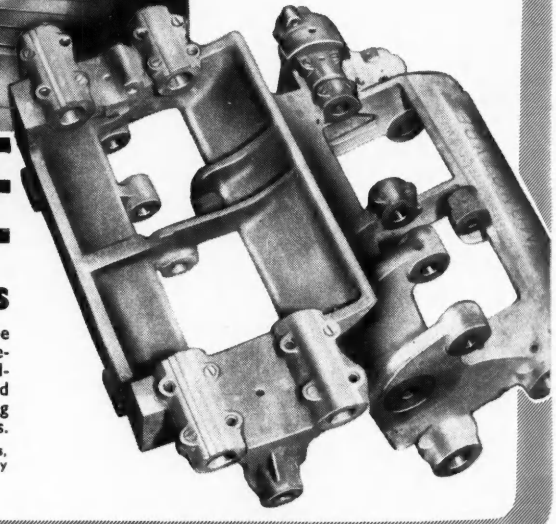

ARCHDALE

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This well-known firm has a world reputation for the high quality and dependable performance of their type-setting machines. Their works are especially well-equipped, and this ARCHDALE 5′ 0″ high speed medium duty radial is fully employed on the drilling and reaming of camshaft stands for casting machines.

These machines are built in sizes from 4′ 0″ to 7′ 0″ spindle radius, are capable of drilling up to 3″ diameter in mild steel, and may have any one of a number of alternative speed ranges.

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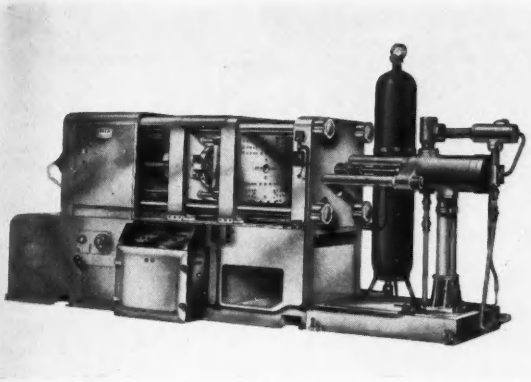


Fig 25

resting on the base, is designed to give a fast initial rate of injection, followed by a slow, high-pressure "squeeze." The danger of porosity in the castings is reduced to a minimum as the change-over from high speed to high pressure is almost instantaneous. The electrical control system for semi-automatic operation is particularly interesting. The whole operation is controlled by push-buttons, and the sequence of the individual stages can be varied at will. Interlocking safety devices ensure that the required sequence is maintained and that the preceding stage is fully completed prior to the start of the next stage. Manual, instead of the semi-automatic, operation can be employed if required. A separate set of push-buttons is provided for setting purposes. A sealed cabinet containing all the electrical control equipment is attached to the front of the machine. Several safety devices are built in, including one which ensures that the operators are well clear of the die parting line before the die closes.

The desire to extend the scope of a measuring instrument is illustrated in the modified design of the Firth "Hardometer" hardness tester, produced by **Firth Brown Tools Ltd.** The machine can now be used without the base plate and anvil, so that by placing it on the edge of a table or bench, large and bulky components can be hardness-tested (See Fig. 26). The table on which the machine is mounted could further bemade portable by providing it with castors. The normal base and anvil are used for testing small components. The machine operates on the principle of the Brinell test, the load being applied by a calibrated spring, and the size of the impression is measured by a microscope. The latter is swung into position after the impression is made. The normal load is 30 kg for a hardness range of 36 to 800 B.H.N., but a similar machine with a load of 10 kg, mainly intended for components having thin carburised or nitrided surfaces, is also available.

A simple and useful new surface finish tester, the Philips PR 9150, is exhibited by **Philips Electrical Ltd.,** London. Although it uses a pick-up, it is strictly a comparator and has to be used in conjunction with a set of surface finish standards. The pick-up incorporating a sapphire needle is passed by hand over the surface to be measured. The needle is connected to a crystal plate having piezo-electric properties. Displacement of the needle relative to the pick-up body as it moves across the surfaces excites an alternating voltage in the plate; this voltage is proportional to the difference in height between the surface irregularities and a zero line. The voltage is amplified, rectified and fed to a moving coil indicating instrument, which thus gives a measure of the surface roughness. The value of the voltage produced is, to a great extent, independent

Fig. 27

of the speed with which the pick-up is moved across the surface. An attenuator in the instrument can be adjusted for four grades of roughness, corresponding to a range of 125 to 2 roughness units. Two sets of standards having the following characteristics are available. Set PR 9180—turning ordinary finish 125 r.u., turning smooth finish 32 r.u., turning very smooth finish 8 r.u., and lapping exceptionally smooth finish 2 r.u. Set PR 9181—milling ordinary finish 125 r.u., shaving ordinary finish 125 r.u., grinding smooth finish 32 r.u., grinding very smooth finish 8 r.u. The reading accuracy is claimed to be better than $\pm$ 25 per cent, the accuracy of the roughness standards + 10 per cent and the total absolute measuring accuracy better than $\pm$ 30 per cent. The whole instrument box measures only $10\frac{1}{2} \times 10\frac{1}{2} \times 7$ in. and weighs about 14 lb. Fig. 27 illustrates the extreme portability and easy use of the instrument.

Another interesting development in the field of measuring and inspection is the new Datum Attachment to be used with the well-known "Talysurf"

(*Continued on page* 318)

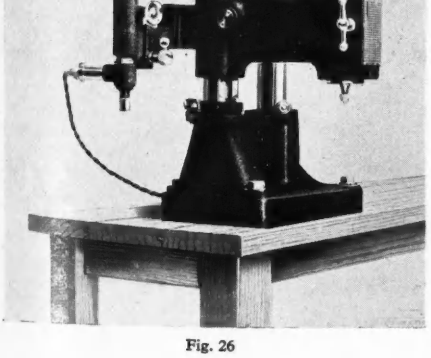
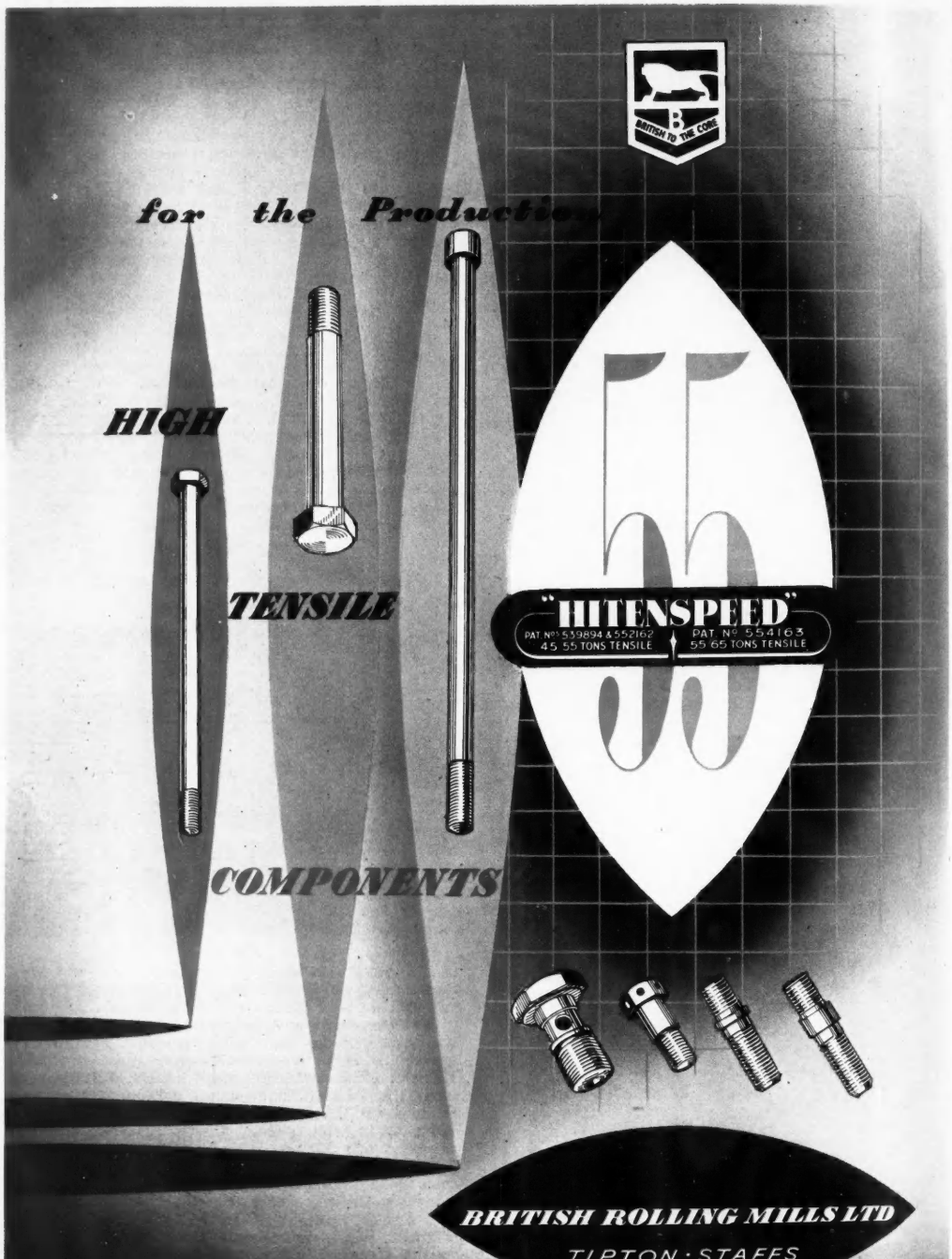


Fig. 26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2nd European Machine Tool Exhibition—Hanover, 1952

The following is a continuation of the review given in our August issue and outlines some further outstanding exhibits to be seen at Hanover. It should be realised, however, that a brief review of this nature cannot include all machines of noteworthy merit on view.

No European machine tool exhibition would be complete without the unique and by now classic machines of Swiss manufacture. The **MAAG Company** of Zürich exhibit a novel giant gear grinder SHS 120. Fig. 11 illustrates this machine, which embodies several departures from the usual Maag designs dictated mainly by the considerable weight of gears up to 4 ft in diameter and 18 in. in width. The gear is mounted on a vertical work spindle, and although

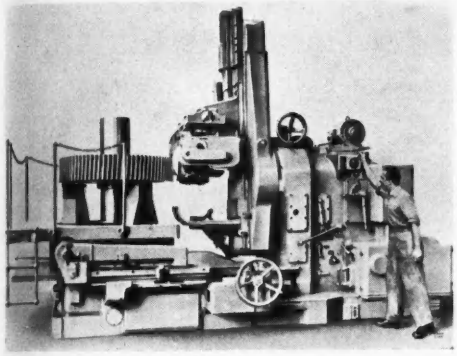

Fig. 11

the basic principle of generation of the tooth flanks is preserved, the mechanism employed is that of a high precision worm and worm-wheel, rather like that of a gear hobbing machine. The machine is provided with the degree of automatic control usually found in Maag gear grinders.

Copying lathes are becoming increasingly popular, and among these several are provided with an automatic cycle control. An example is the "Profilomatic" duplicating lathe of the firm **Maxnovo** of Novara, Italy. In this machine all operations except the loading and unloading of the component are entirely automatic, including the changes of spindle speeds and tool feeds. Several constructors advertise the maintenance of a constant cutting speed, and in some cases this is obtained by means of electronic control of the driving motor, though little information is given on the control circuits.

A characteristic trend is the design of machine frames and beds to take account of the direction of cutting forces and ensure the maximum rigidity for the tool carriage. This is well illustrated in the **Georg Fischer** copying lathe, details of which have been described in an earlier issue of this journal.

Several new tool grinding machines will be found in the Exhibition. Most are designed on accepted principles, but the demands of high precision are continually increasing, and certain features of detail design normally found in production grinding machines are now entering the tool grinding field. Among the special machines in this category the broaching needle sharpener by **Oswald Horst** of Solingen is illustrated in Fig. 12.

A number of automatic lathes is exhibited, several of which are shown for the first time. Although no new principles of design can be detected, the general trends of higher speed, improved stiffness, better handling, easier tool change, and protection against swarf, continue to introduce new forms and lay-outs. The multi-spindle automatic lathes (Fig. 13) by **Alfred H. Schütte,** of Cologne, shown this year for the first time, are a remarkable example of this gradual improvement.

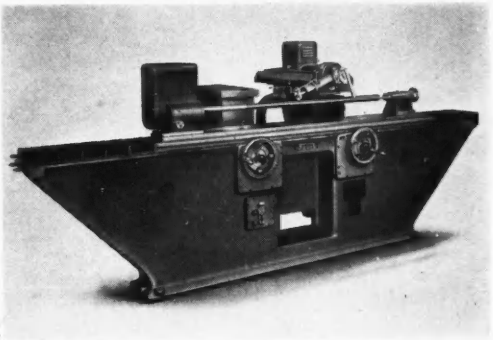

Fig. 12

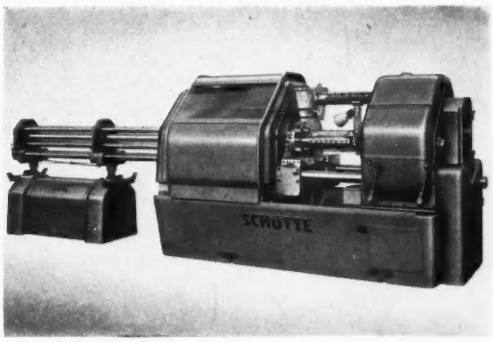

Fig. 13

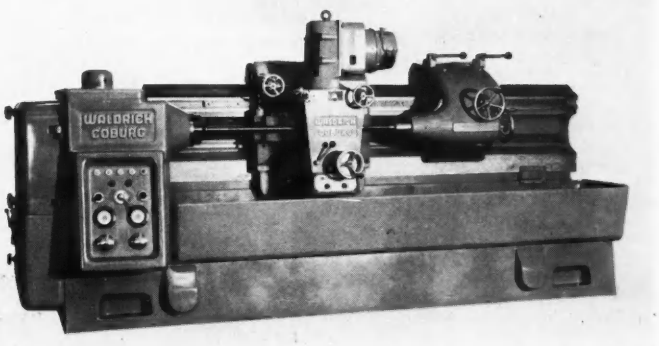

Fig. 14

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INTERNATIONAL MACHINE TOOL EXHIBITION, London, 1952—See our Exhibits on STAND 61, OLYMPIA, Sept. 17—Oct. 4.

Several exhibitors show special machines for the cutting of very long threads. Among these the **Waldrich Coburg** model GS 65 is capable of maximum diameters up to 5in. and maximum lengths between centres of up to 80 in. This machine, illustrated in Fig. 14, has been specially designed to take full advantage of the cutting capacity of carbide tools. It is said that the cutting time is less than one-tenth of that needed in thread milling. The high cutting speed ensures a smooth surface, which often makes thread grinding superfluous. The accuracy of the thread produced is within the tolerances laid down for leadscrews. An index attachment enables the cutting of multiple-start threads.

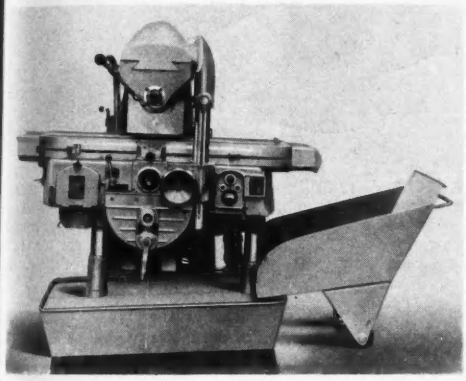

Fig. 15

The climb milling process, also known as down milling, has found widespread use in large-scale production, and its advantages are well-known to most production engineers. These advantages are the ability to take heavier cuts without introducing roughness of the machine surface, increased life of cutter, simpler clamping of the component and reduced power demand. They are exemplified in the milling machines exhibited by **Maschinen- und Gerätebau Gmbh,** of Berlin, under the trade name " Jerwag Milling Machine," FW 355/1000 Fig. 15. This organisation is a pioneer of climb milling, and has specialised in the construction of milling machines particularly adapted to this process. This year, a universal milling machine FWU 355/1000, is also shown which dispenses with the swivelling table and replaces its angular freedom by that of a universal milling head.

Shaping machines are often the " Cinderella " of toolrooms and other workshops for appearance, precision, and variety of ancillary equipment. A distinctly modern look distinguishes the S 280 High-Capacity Precision Shaper displayed by **Karl Anderle,** of Steyr-Gleink, Austria. Though the basic mechanism of the machine is conventional, it possesses a novel equipment such as a universal table with two swivelling axes (Fig. 16), a circular planing device (Fig. 17), and a specially adapted milling head supplied with a separate driving motor which can replace the reciprocating ram of the shaper.

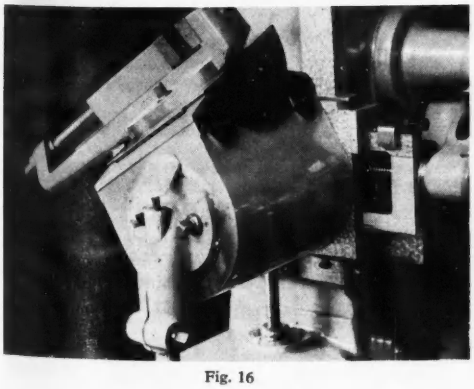

Fig. 16

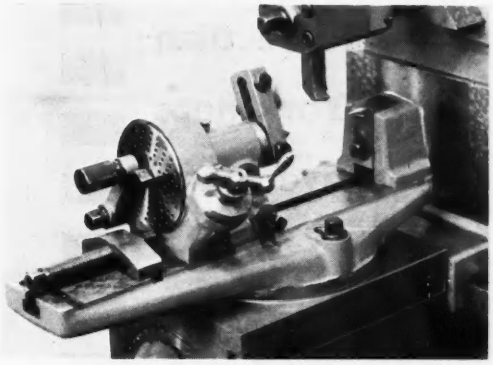

Fig. 17

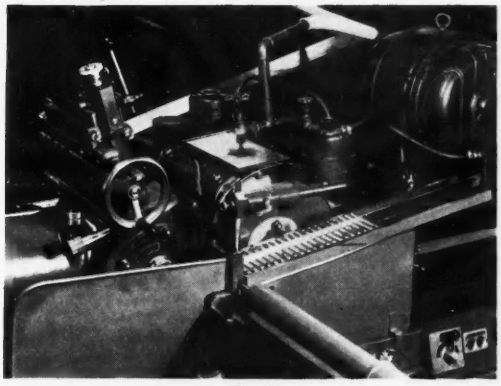

Fig. 18

In addition to their centreless grinders, **A-B Malcus Holmquist,** Halmstad, Sweden, exhibit some novel auxiliary devices for feeding these high-production machines. Centreless grinders sometimes achieve higher output by simultaneous machining of two components. The introduction of the components into the machine is shown in Fig. 18. The control of the regulating wheel speed is accomplished within wide limits by means of a Ward-Leonard unit. This unit is also used to drive a special bar magazine feed shown in Fig. 19, which introduces bar stock into the grinder at a rate determined by its advance through the machine. A rotary feeding attachment supplied from a magazine with a capacity of up to 35,000 small components, such as bearing needles, is shown with the smaller centreless grinder. The centreless grinders, as well as the surface grinder with hydraulically driven table made by the same firm, are provided with built-in truing devices. The surface grinder has an adjustable profile guide for truing the grinding wheel to any desired shape.

A saw-tooth sharpening machine for truly universal use made by **A. H. Schmidt,** of Stuttgart, Germany, under the trade mark " Tempo," is exhibited together with a variety of attachments for circular saws, hacksaw

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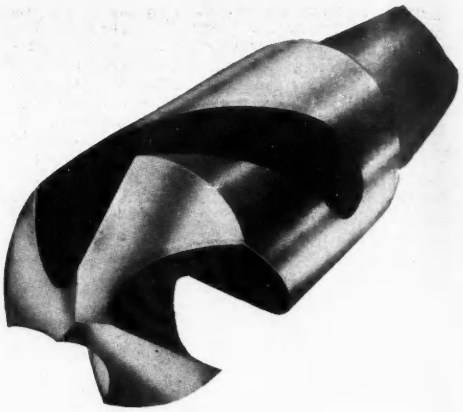

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SBS-B — Twist Drill Grinding Machine. Drill Capacity 12-30 mm ϕ (0.47″-1.18″).
SBS-C — Twist Drill Grinding Machine. Drill Capacity 30-80 mm ϕ (1.18″-3.15″).
SBS-F — Twist Drill Grinding Machine. Drill Capacity 3-32 mm ϕ (0.12″-1.26″).
GBS — Tap Grinding Machine to back-off the tapered section of all taps. Capacity 4-50 mm ϕ (0.16″-1.96″).
AS-1 — Web Thinning Machine for Twist Drills Capacity 8-80 mm ϕ (0.32″-3.15″).

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We look forward to the pleasure of seeing you at our **Stand No. 2104 — Hall 2, at the 2nd European Machine Tool Exhibition, Hanover, 14th. to 23rd. September, 1952.**

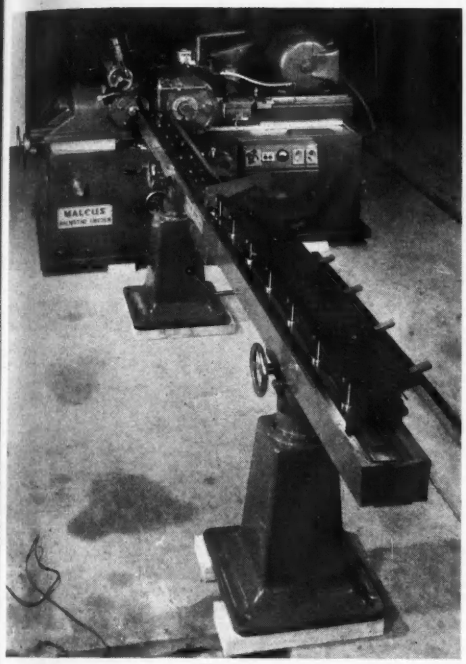

Fig. 19

blades, and band saws. The latter attachment is shown in Fig. 20. The makers claim a specially high degree of indexing accuracy. The indexing speed is capable of infinite variation between 40 and 150 steps per minute. This machine can be provided for dry or wet griding and, when operating dry, dust-extracting and collecting equipment can be supplied.

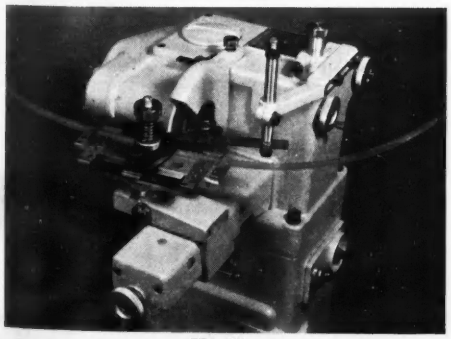

Fig. 20

A new principle in the design of mechanically operated stamping presses is employed in a series of models shown by **May-Pressenbau Gmbh,** Schwäbisch Gmünd. The mechanical principle is that of the toggle mechanism used in tension, associated with a bell crank. This principle brings a number of decisive advantages in comparison with mechanically-operated pressures using the eccentric principle or the toggle mechanism with its links in compression. Technically, the advantages are best illustrated by means of a diagram, Fig. 21, which shows the relation between pressure and position of ram.

The main advantage bearing on the stamping process itself can be read from the diagram. Assuming

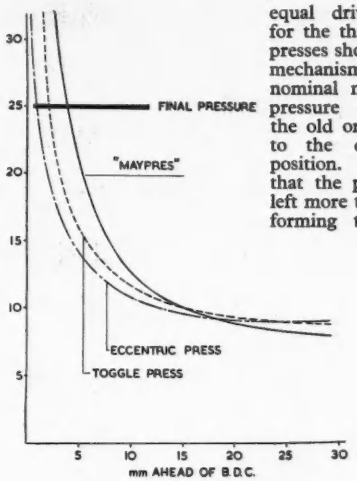

Fig. 21

equal driving torque for the three types of presses shown, the new mechanism achieves the nominal maximum of pressure earlier than the old one in relation to the dead centre position. This means that the press tool is left more time for performing the pressing operation. The makers claim that this feature improves the surfaces in press cutting and, above all, considerably increases the life of the tool.

An advantage in the general lay-out of the press is the fact that the driving motor is naturally placed on or below the floor, a desirable feature for all presses. The main feature of the new principle lies in the design of the press inasmuch as the mechanical chain, comprising the toggle links, the bellcrank, the ram, the ram press tool and the table, alone carries the large pressure loads. The body of the press is almost unloaded, and can therefore be designed for convenient operation. Thus, a gap body, Fig. 22, can be retained up to higher pressures than otherwise possible (60 tons), and even the 100-ton press, Fig. 23, is still considerably lighter than conventional presses of the same capacity. The advantages in factories several storeys high are obvious.

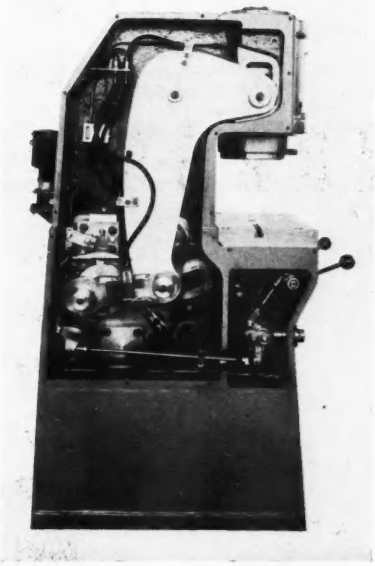

Fig. 22

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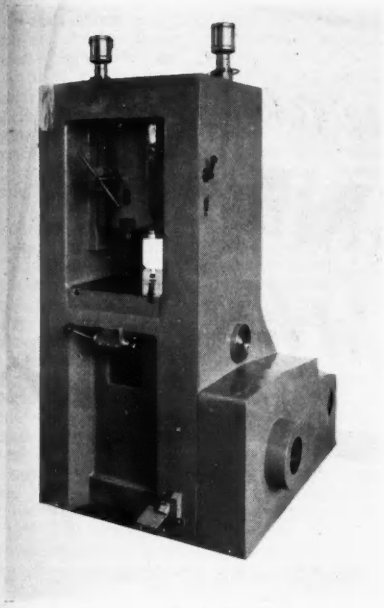


Fig. 23

A toolroom and production lathe for small and medium components is shown by **M. de Valliere,** of Boulogne-sur-Seine, France. This machine, Fig. 24, answers a growing demand for a really modern lathe for high-precision work in small sizes. In its lay-out and detailed design, convenience of control organs, numbers of feeds and speeds, this lathe has all the features expected today of a first-rate toolroom machine. The tailstock spindle can be moved either by a nut and screw mechanism, driven by a handwheel, or a rack and pinion mechanism, the pinion of which is directly attached to a four-arm spider. This arrangement enables the use of the lathe as a capstan lathe with a multiple tool mounted on the tailstock. The taper turning attachment permits a rapid change-over from cylindrical to conical turning, without disengagement

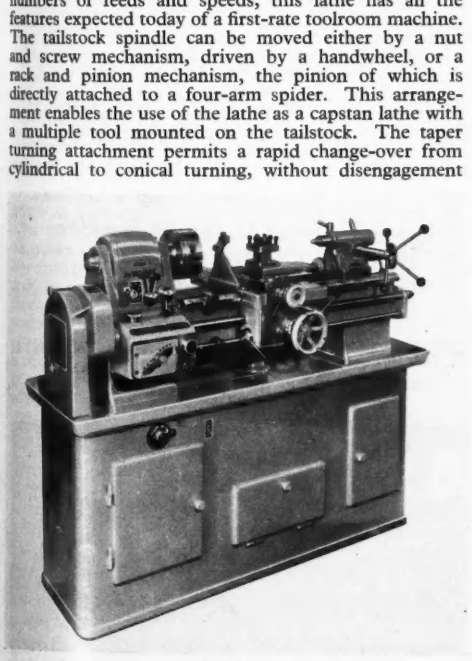


Fig. 24

Fig. 25

of the lead screw or any of the other drives of the cross-slide, including the rapid return of the tool. The same firm also exhibits a small precision boring machine for production work, which can be supplied as a single or a multi-spindle unit. An example of a four-spindle machine is shown in Fig. 25. These machines are provided with automatic stops which ensure high precision of the diameter and length of the finished bore.

These trends can be observed on the stands of leading firms in press construction. Among these **Eumuco A.G.,** Leverkusen-Schlebusch, exhibit no fewer than four new machines this year. The die forging and calibrating press, "Maxima," with a pressure of 650 tons, has now been brought up to an increased number of strokes reaching 130 per minute, associated with a higher pressing speed of up to 1·3 metres per second. The continuous development of these presses is due to the growing recognition that die-pressing often allows considerable saving of raw material and improved accuracy of the product as compared with die-forging. The high pressing speed reduces the interval during which the forging and the die are in contact, and thereby preserves the heat of the forging. This advantage can, of course, be utilised in a number of ways, namely, either allowing more work to be done in a single "heat," or improving the life of the tool. The makers claim that the customary precision in controlling the exact stop of the ram in

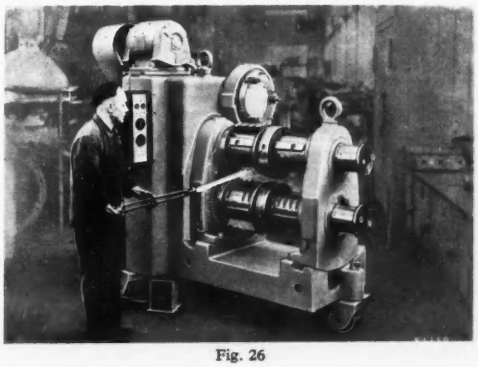
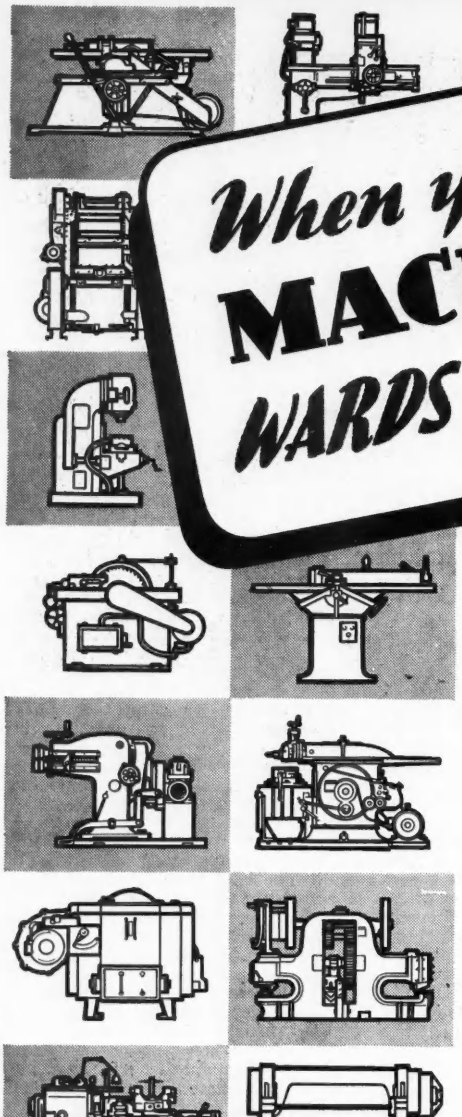


Fig. 26



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its top dead centre is not impaired, owing to this firm's clutch and brake design, continuously developed to meet increasing demands.

A fully modernised version of an old forging machine, known as the forging roll, is exhibited this year (Fig. 26). The main use of this machine is in the swaging of drop forgings. Compared with the drop-hammer, the forging roll gives much better uniformity and considerably higher output. The operator is afforded complete control over the movement of the roll and its stops. For short pieces, two segments can be placed on the rolls, shifted by 180 deg., and thereby the output of the machine can be increased.

The high-speed drop hammer on show is claimed by the makers to combine the essential advantages of steam- or compressed air-driven drop hammers, namely, their high capacity, with the low power consumption of the direct electric drive. The machine has an impact energy of 1,600 mkg, and its speed ranges from 50 blows per minute for maximum impact energy to 80 blows per minute for smaller drops. The basis of the drive is an electric motor which rotates a flywheel through a V-belt transmission. The lifting, suspension and release of the ram are essentially controlled by the pneumatically operated system of friction clutch and brake. The ram can be stopped in any desired position and the whole control is manipulated by a single operator. The reversal of ram motion at the instant of impact is performed automatically.

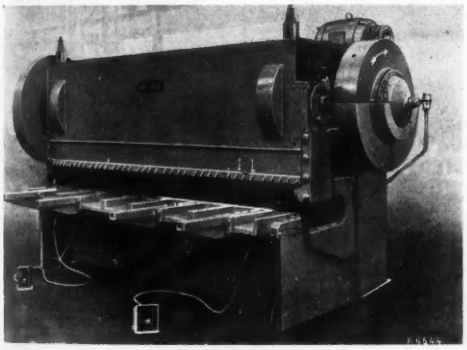

Fig. 27

A new design of a guillotine for the cutting of plate edges in preparation for welding is shown in Fig. 27. The machine is distinguished by the arrangement of an upper cutting blade which can be swivelled in a few seconds by an electric motor under push-button control, so that any angle of cut up to 35 deg. can be performed. The cutting angle can be read-off on a repeater scale at the control desk. The plate is held down by elastic clamps exerting, according to the maker's claim, a multiple of the usual clamping pressure. The plate is positioned either by means of a stop which can be adjusted from the control desk with the help of an electric motor, or else its position is shown up by a "shear line indicator." The machine automatically disengages at the end of the cutting stroke.

A range of heavy presses is exhibited by **Th. Kieserling & Albrecht K.G.,** Solingen. A large crank press with a wide housing, giving a pressure of up to 800 tons, is shown in Fig. 28. The press is equipped with cushioning compressed air cylinders to improve smoothness and reduce noise. An indicator dial is provided which shows the adjustment of the ram to an accuracy of 0·1 mm. The machine is fitted with overload safety devices and warning light signals. These are arranged separately for the two sides of the ram, so that non-symmetrical overloading affects only one safety device, and is shown up by the appropriate

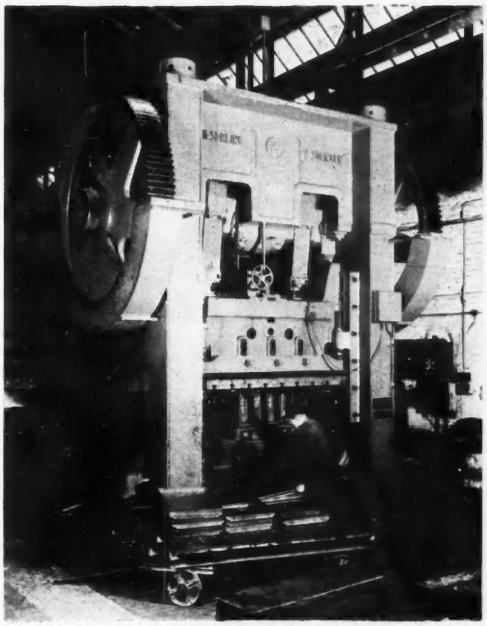

Fig. 28

warning light. The press is manipulated by push-button control, which operates through a pneumatically actuated clutch and brake system. A toggle coining press of 600 tons pressure is also exhibited which has a rapid height adjustment by a push-button controlled electric motor, and a mechanical air-operator ejector. The range of presses continues with a 160-ton eccentric press with a fixed table, which includes ram adjustment and automatic ejection. A 50-ton eccentric press is fitted with an adjustable table, and a small 32-ton eccentric press has a fixed table and a roller feed device.

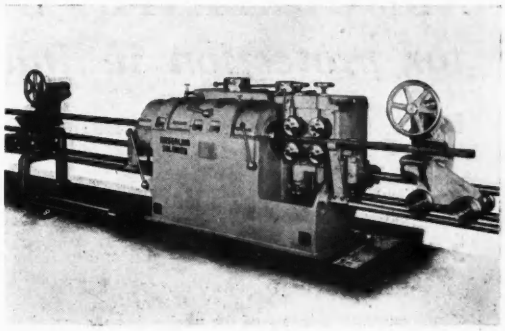

Fig. 29

Apart from their wide range of presses, the same company also exhibit a horizontal bending machine (bulldozer), working on the crank press principle, and a hot nut press with automatic feeding device, and water-cooling of the dies. Finally, a centreless shaft peeling machine (Fig. 29) is shown at work at the Exhibition. The machine can take shafts of up to 80 mm dia. and carries out work to 1-3 thou, limits on diameter. Speed and feed control are stepless. A polishing head can be supplied with the machine.

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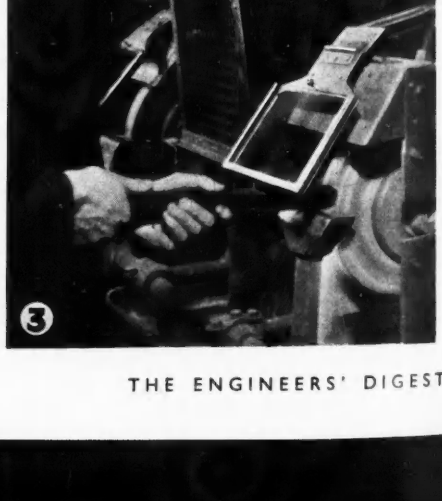

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NEWS OF THE MONTH

PERSONAL

Mr. Campbell Adamson, M.A.(Cantab.), has been appointed personnel superintendent of the Steel Company of Wales Ltd., in succession to **Mr. Glyn M. Jones** who relinquished his position for health reasons but is continuing in an advisory capacity.

Mr. C. T. M. Bagnall has been appointed publicity manager, and **Mr. M. B. Schroeder** has been appointed assistant publicity manager of The English Electric Company Ltd. **Mr. A. E. L. Jervis** has joined the Department as trade and technical press officer on 1st July. The Publicity Department has recently moved to Marconi House, Strand, London, W.C.2. Telephone: TEMple Bar 1577.

Air Commodore F. R. Banks, C.B., O.B.E., (Rtd.), has been appointed Principal Director of Engine Research and Development at the Ministry of Supply. He will be responsible for the Ministry's research and development programme for aero engines. Air Commodore Banks, who is 56, has been specially released by the Associated Ethyl Co., Ltd., for whom he was Technical Manager, to take up this appointment. The Ministry acknowledges the generous action of the Company in making him available. During the war, Air Commodore Banks served successively as Director General of Engine Production and Director of Engine Research and Development in the Ministry of Aircraft Production.

Mr. R. Bridgman has been promoted to assistant chief engineer in the Nigerian Railway. **Mr. J. D. Gwynne, B.Sc.,** Poughill Road, Bude, Cornwall, and **Mr. P. R. Olliver, B.Sc.,** 80 Chippingfield, Harlow, Essex, have been appointed to the Colonial Engineering Service in the East Africa High Commission.

Mr. P. Butler, B.Sc., M.I.E.E., and **Mr. W. B. Laing, Assoc. Heriot-Watt College, M.I.E.E.,** have been appointed directors of Bruce Peebles & Co. Ltd., Edinburgh 5.

Mr. T. S. Charlton, J.P., production director of the South-Western Division of the National Coal Board, has been appointed deputy chairman of the West Midlands Division, Himley Hall, near Dudley, Worcestershire, in succession to **Alderman G. H. Jones, O.B.E., J.P.,** who is retiring at the end of September. **Mr. G. S. Morgan,** general manager of No. 4 area of the South-Western Division, at Aberaman, Aberdare, will succeed Mr. Charlton as production director.

Dr. S. F. Dorey, C.B.E., M.I.C.E., M.I.Mech.E., F.R.S., chief engineer surveyor of Lloyd's Register of Shipping, has been elected senior vice-president of the Institute of Metals.

Mr. S. B. Gates, O.B.E., M.A., A.F.R.Ae.S., of the Royal Aircraft Establishment, has been appointed chief scientific officer, **Sir Donald C. Bailey, O.B.E., D.Eng., A.M.I.C.E., M.I.Struct.E.,** of the Military Engineering Establishment, Ministry of Supply, has become deputy chief scientific officer, and **Dr. F. E. Jones, M.B.E., B.Sc.(Eng.), A.M.I.E.E.,** of the Telecommunications Research Establishment, Ministry of Supply, has also been promoted to deputy chief scientific officer.

Mr. G. E. Godfrey, M.B.E., A.M.I.Mech.E., has been appointed managing director of Brynmawr Rubber Ltd., a subsidiary company of Enfield Cables Ltd.

Mr. T. E. Goldup, M.I.E.E., a director of Mullard Ltd., has been appointed Chairman of the Board of Governors of the Ministry of Supply School of Electronics, Malvern, in succession to **Professor Willis Jackson, D.Sc., D.Phil., M.I.E.E.,** Professor of Electrical Engineering, City and Guilds College, London.

Mr. G. B. Harper has been appointed transformer engineer in the transmission design branch of the British Electricity Authority at headquarters, Great Portland Street, London, W.1.

Mr. Ronald Kendall relinquished his position of editor of The Shipping World to become managing director of Burness, Kendall & Partners, marine consultants and naval architects, 15 St. Helen's Place, London, E.C.3, and a director of Burness Shipping Co. Ltd.

Brigadier The Hon. H. K. M. Kindersley has been appointed deputy chairman of Rolls-Royce Ltd., Derby. **Sir Colin W. Weedon, K.B.E., C.B.,** joined the firm on his retirement from the Royal Air Force. He will be concerned with the export side of the aero-engine division.

Mr. F. Marshall, B.Met., has joined the metallurgical staff of the Research and Development Division, British Steel Founders' Association, 13 Broomgrove Road, Sheffield 10.

Mr. C. T. Melling, M.Sc., M.I.E.E., M.I.Mech.E., has been elected President of the Association of Supervising Electrical Engineers, 54 Station Road, New Barnet, Hertfordshire.

Air Commodore W. A. Opie has been appointed director of servicing research and development, Ministry of Supply, in succession to Air **Commodore G. B. M. Rhind, B.A.,** who has been appointed senior technical staff officer at Headquarters, 2nd Tactical Air Force, Germany. **Air Commodore L. R. S. Freestone** has been appointed director of armament engineering at the Air Ministry.

Mr. Roy C. Orford, M.Sc., C.P.A., A.M.I.E.E., has been appointed patents manager to Power Jets (Research and Development) Ltd.

Mr. J. W. Pringle, chief technical officer (utilisation) of the Northern Gas Board, has been appointed chief development officer to Thomas de la Rue & Co. Ltd., Warwick.

Mr. Stewart Salmond, F.R.I.C.S., Assoc.I.C.E., and **Mr. L. G. Boen, B.Sc., M.I.C.E.,** have become partners of Sir Alexander Gibb and Partners, consultant engineers, Queen Anne's Lodge, London, S.W.1. **Mr. Salmond** will be resident partner at the Edinburgh office and **Mr. Boen** will be normally in London.

Mr. T. R. B. Sanders, C.B., has been appointed engineering adviser to the British Standards Institution.

Air Commodore G. S. Shaw, C.B., R.A.F.(retd.), has been appointed group liaison officer to the Hunting Group of Companies, 26 Ryder Street, London, S.W.1.

Mr. E. G. A. Singleton, M.I.Mech.E., engineer and deputy general manager, Wolverhampton Corporation Transport Department, has been appointed general manager and engineer of the Burton-on-Trent Transport Undertaking. He will take up his new duties on October 1.

The Minister of Supply (Mr. Duncan Sandys) has appointed, with effect from 1st September, **Rear Admiral M. S. Slattery, C.B., R.N.(Ret'd.)** to be Chairman of Short Brothers and Harland Limited, Belfast. He succeeds Sir Edward Herbert, who has resigned owing to the greatly increased pressure of his other business interests.

Admiral Slattery has been managing director of the Company for the past 4½ years. He is 50 years old and had a distinguished career in the Royal Navy, and during the years 1939 to 1948 held a number of important appointments in the Admiralty, the Ministry of Aircraft Production and the Ministry of Supply in connection with the devlopment and supply of aircraft for the Royal Navy.

In accepting Sir Edward's resignation the Minister has recorded his thanks for the valuable services he rendered to Short Brothers and Harland Limited during the 7½ years that he has been its Chairman, a period which included the post-war reorganisation, the transfer of the main works from Rochester, and the re-establishment and development of the entire organisation in Belfast.

Mr. J. Foster Veevers, M.I.E.E., M.I.P.A., M.I.I.A., formerly manager of the Stockport Works of Salford Electrical Instruments Ltd., has been appointed general manager of the Swindon Works of the Plessey Co. Ltd.

Mr. A. W. Waterfield, B.Sc., 24 Whitmore Road, Harrow,

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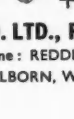

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Middlesex, has been appointed to the Colonial Engineering Service in Malaya.

Mr. G. Ridley Watson, M.I.N.A., M.I.Mar.E., London manager of White's Marine Engineering Co. Ltd., Hebburn-on-Tyne, has been appointed a director of the Company. He will continue at the firm's London office at 43 Billiter Buildings, 49 Leadenhall Street, E.C.3.

Mr. G. L. F. Welham, A.R.Ae.S., has been appointed deputy managing director of the Holbrook Machine Tool Co. Ltd., 44-48 Martin Street, London, E.15.

Mr. K. J. Whitehead has been appointed a director of the Wolverhampton Die Casting Co. Ltd., Graiseley Hill, Wolverhampton.

Mr. H. J. Finden, M.I.E.E. who is responsible for the development and design of electronic instruments in The Plessey Company Limited, Ilford, Essex, is to read a paper on Developments in Frequency Synthesis at the conference on Instruments and Measurements, Stockholm, 22nd-25th September, 1952, arranged under the auspices of The Royal Academy of Engineering Sciences (IVA) and The Association of Technical Physicists (TFF).

The paper develops the method of synthesis of frequencies previously described by the author and refers to equipment in which the frequency has been extended to 100 Mc/s. Consideration of the significant products of the mixing process leads to solutions whereby the lowest order of harmonics can be determined.

An equipment is described in which the selection of the correct frequency to be mixed is achieved automatically by motor driven harmonic selector switches controlled by manual digit dials. The purity of the output is such that all unwanted products are attenuated by at least 70 dB. Any kc/s step between 1 kc/s and 100 Mc/s can be obtained with the accuracy of one frequency standard. Alternatively any frequency in the spectrum can be generated with an additional inaccuracy of ± 1 c/s.

OBITUARIES

We announce with deep regret the death of **Mr. Cyril Charles Claxton,** Secretary and Joint Managing Director of The Sheffield Twist Drill & Steel Co. Ltd., who died on the 8th August, 1952 in Sheffield at the age of 53.

After joining the firm at an early age, he spent four years in the United States of America gaining engineering experience. On his return in 1924 he understudied his father the late Charles William Claxton at the Company, becoming a director in 1936, and after the latter's death in 1943 became Joint Managing Director.

He leaves a widow, two sons and two daughters.

His loss will be keenly felt by the Company and by the various trade Associations connected with the Engineers' Small Tool Industry.

We announce with deep regret the death at Kingussie, Inverness-shire, in his 78th year, of **Mr. J. Baptist Kramer,** scientist, inventor, and pioneer in the field of magnetism as applied to industry. Mr. Kramer founded the Witton Kramer Electric Tool and Hoist Works, of which he was general manager, in 1909 and worked in collaboration with the General Electric Company Ltd. until his retirement 30 years later.

Mr. Kramer was best known for his work on the development of magnetic cranes in this country, and in the use of photo-electric cells as detector devices.

In both World Wars Mr. Kramer gave valuable service to the country. During the last war in addition to working on anti-submarine devices, he co-operated with the Royal Navy in producing a smoke-detector which gave warning to a ship when its own smoke became visible. Another invention was a safety device for use when unexploded bombs were being dealt with.

Mr. Kramer gave many lectures and demonstrations of his work in all parts of the country. He was the author of a number of scientific publications, one of the most notable being "Radiations from Slow Radium" published in 1921.

BUSINESS NOTES

The Caledonian Tractor & Equipment Co. Ltd., 1 Rigby Street, Glasgow, E.1, announce a patented universal attachment for tapping and other operations. This "Jay-Dee" attachment uses no springs, but incorporates a patented Duplex power cushion which acts in conjunction with a slipping dog clutch and permits the attachment to remain in position for all drilling, tapping, spotfacing, studding and similar operations.

The attachment is designed for use on all drilling machines, turning and boring mills, and combination lathes, where it readily undertakes the duties of any three turret stations.

Johnson and Phillips Ltd. have appointed China Engineers Ltd., 41 Chartered Bank Chambers, P.O. Box 565, Singapore, sole agents in Singapore and Malaya.

Conveyancer Fork Trucks Ltd., Liverpool Road, Warrington, announce that **Mr. C. E. Montague** has left for Australia to assist in the formation of an associate company, Conveyancer Fork Trucks (Australia) Pty. Ltd. **Mr. J. N. Kirby, Mr. W. Gwinnett** and **Mr. C. E. Montague** will be resident Australian directors.

The Balfour Group of Companies and **W. S. Barron & Son Ltd.,** Gloucester, have formed, in association with Canada Ironfoundries Ltd. and Dominion Wheel and Foundries Ltd., a new Canadian company, British and Dominion Process Engineering Ltd.

Saben, Hart & Partners Ltd., design consultants, have moved from 3-4 Albemarle Street, London, W.1, to larger premises at 207-213 Oxford Street, London, W.1. Tel.: GERard 9622-5.

The 4th International gathering of associates and distributors of the **Driver-Harris** organisation will be held at Alderley Edge, Cheshire, on October 8th, 9th, and 10th, and will constitute a Technical Development Conference. A number of technical papers (previously circulated) dealing with the various aspects of the Driver-Harris alloys and new fields of application will be discussed.

The Climax Rock Drill and Engineering Works Ltd. has opened a new sales, service and spares branch office at High Road, Earlsheaton, Dewsbury. 'Phone: Dewsbury 2190. The Branch Manager is Mr. R. Sheffield.

The British Thomson-Houston Company has received from the U.S. Army, European Headquarters Command, an order for military electronic equipment valued at approximately 4,200,000 dollars.

Dale Electric (Yorkshire) Ltd., Filey, Yorkshire, have received Canadian Standards Association approval (No. 11750) for their automatic, semi-automatic and hand control Diesel Generating Plants. Dale Electric manufacture a range of fully automatic, remote control and hand starting type generating units, petrol and diesel engine driven, in sizes from 500 watts to 28 kVA The export division of this company, Dale Electric (Export) Ltd., have their offices at 28, Eccleston Street, London, S.W.1.

The British Thomson-Houston Co. Ltd. have developed and are introducing to this country a range of capacitors of entirely new design to replace the petroleum jelly type previously used for fluorescent equipment.

The new capacitors are exceptionally compact and have a "Permitol" impregnated paper dielectric, housed in an all-welded leakproof aluminium case. They have the advantage of clamp type terminals for easy wiring and are fitted with discharge resistors. They are suitable for use at ambient temperatures in the region of 70 degrees centrigrade.

"Permitol" is a chemically stable, non-inflammable material having excellent insulating properties, including a high dielectric constant. These properties enable a capacitor of a given rating to be produced in a much smaller overall size compared with a jelly impregnated type.

The factory of **Hoover (Washing Machines) Limited** at Merthyr Tydfil, Wales, which in mid-June went on to a shortened working week of four days, has returned to a five-day working week.

Building development work at the Merthyr Tydfil factory, which is nearing completion, will bring the total floor space there to some 200,000 square feet, which is three times the amount which was available when the factory was opened in 1948. Additional plant, worth some half a million pounds, is in course of installation in the factory extension.

Mr. A. R. Northover, the resident director and manager of the Merthyr Tydfil factory and the subsidiary factories at Cyfarthfa and Aberdare, is now assisted in his added responsibilities by the appointment of **Mr. F. Austin** to works manager at Merthyr Tydfil. **Mr. J. Hallifax,** production engineering superintendent, has taken charge of the High Wycombe factory, in succession to **Mr. Austin.**

Electrical Remote Control Co. Ltd. has taken over a new factory. Their new address is Elremco Works, East Industrial Area, Harlow New Town, Essex. Tel.: Harlow 3032.

W. Crockatt & Sons Ltd., Darnley Street, Glasgow, S.1, have been appointed sole representatives for Scotland for Pelapone Engines Ltd., Derby.

The Ministry of Supply announces that it has been decided to place a production order with Blackburn and General Aircraft for the Universal Freighter for use by the R.A.F.

David Brown (Australasia) Proprietary Limited, 82 Pitt Street, Sydney, Australia, has been formed for the distribution throughout Australasia of agricultural tractors and implements, industrial tractors, stationary engines and marine engines manufactured by David Brown Tractors (Engineering) Ltd., of Meltham, Yorkshire. Mr. P. J. Clifford has been appointed Manager of the new company.

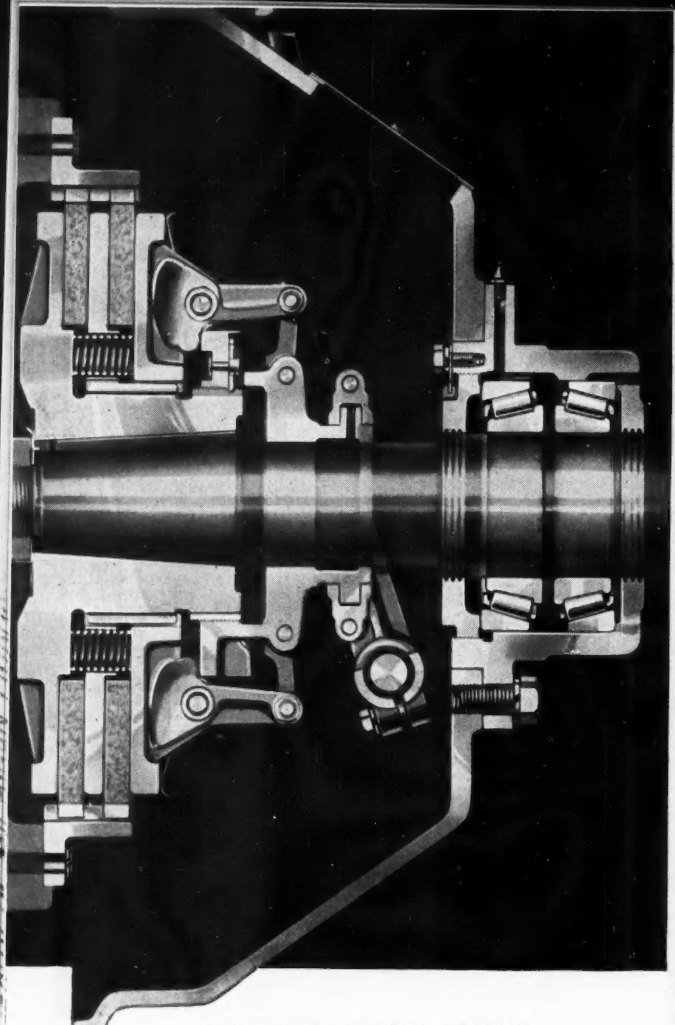
A **new Tool Room Heat Treatment Department,** mainly comprising Salt Baths has recently been completed at the works of The Reynolds Light Alloys Ltd., Redditch, for the treatment of both tools and dies. The new plant, including fume extraction equipment, was supplied and installed by McDonald Furnaces Limited, Dawley Brook, Kingswinford, Staffs., and comprises:—

Twin Chamber Gas Fired Salt Bath for Pre-heating and Drying, Gas Fired Tempering Salt Bath and High Temperature Electrode Salt Bath.

"Basic Principles of Lubrication," an instructional film made for the Esso Petroleum Company, Ltd., by Technical Films Ltd., has met with remarkable success. In the Scientific Section of the Venice Film Festival it gained the second prize, being in fact the only film of its type to get an award.

It has also had the unusual distinction of being shown twice at the Edinburgh Festival in both the Educational and Scientific Sections. Now it has been booked for showing at the 6th Congress of the International Scientific Film Association to be held in Paris from 23rd September to 1st October.

Dr. F. P. Bowden, Sc.D., F.R.S. (Laboratory for the Physics and Chemistry of Surfaces at Cambridge University) acted as scientific adviser to the makers of this film, which is designed to present, in a form comprehensible to the non-technical as well as the technical audience, an explanation of the basic phenomena of lubrication. It is being used by Government Departments and industrial firms in this country, and requests for copies have already been received from the U.S.A. and India.



POWER TAKE-OFFS AND CLUTCHES

The well-known Rockford heavy-duty clutches and power take-offs are being made by us at Leamington Spa. They are used with industrial petrol, paraffin and diesel engines driving agricultural machines, generators, compressors, pumps, winches and other machines.

These clutches are expressly made for heavy duty, have a toggle action which holds the clutch firmly in the 'in' or 'out' position without end thrust. The only adjustment necessary can be made without the need for special tools or the manipulation of special locking devices.

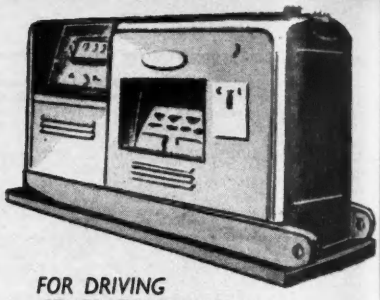
Rockford clutches, and when necessary, power take-offs, are made for powers up to 13·6 h.p. per 100 r.p.m. or a maximum torque of 1,050 lbs./ft.

A power pack fitted with the Rockford clutch and power take-off can be used for any normal or emergency purpose.

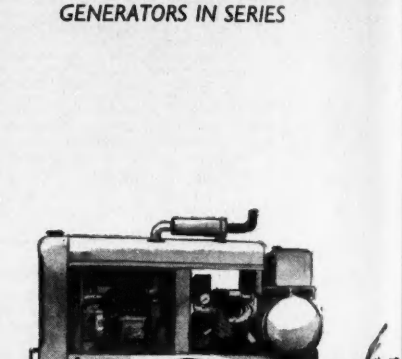
Descriptive catalogue, with list of standard sizes, on application from :

BORG & BECK COMPANY LIMITED, Leamington Spa, England

ROCKFORD



FOR DRIVING GENERATORS IN SERIES



FOR COMPRESSORS

FOR DRAG LINE EXCAVATORS

SUPERVISORY EQUIPMENT FOR THE INDICATION OF SHAFT DISTORTION IN STEAM TURBINES

When steam is applied to a turbine preparatory to starting up, the rotor, having less weight and heat capacity than the casing, heats up more quickly. This causes the shaft to expand in relation to the casing, and care must be taken to see that the motion so caused does not exceed the clearance allowed at various points within the turbine. Similar movements take place when there is any sudden change of load or when the machine is shut down, and similar precautions must be taken.

Moreover, if during starting there is unequal application of heat around the rotor, the resulting unequal expansions tend to bend the shaft slightly, causing those parts of the rotor not adjacent to the bearings to rotate eccentrically. This sets up out-of-balance forces which tend to increase the distortion of the shaft and, if due care is not exercised, it is possible for the eccentricity of motion to exceed radial clearances, so that rubbing and consequent damage may ensue.

In order to reduce these dangers, it is customary to start the turbine according to a time schedule long enough to ensure fairly uniform heating, thus avoiding the possibility of clearances being reduced below those allowable for safe operation. It is likely that this period could be shortened, if precise knowledge of the relative displacements in the turbine were continuously available. With this information plant could be more readily brought into use, particularly at critical load periods.

Similarly, the record of the shaft movement correlated with rotational speed throughout the life of the turbine would enable any progressive deterioration to be ascertained and would permit subsequent analysis of machine performance.

Supervisory equipment for the indication of shaft distortion in steam turbines is being installed in each of the six 60 MW turbines for the new Generating Station of the B.E.A. at Uskmouth, Newport, Mon. Developed by the Research Laboratories of The General Electric Company Ltd. for the Fraser and Chalmers Engineering Works, the equipment was connected to the first of these turbines when undergoing steam trials. The distortions of the shaft, though small, were easily observed and a much clearer idea of the relative movements of the various parts was obtained than would have been possible if the supervisory equipment had not been available.

With the equipment, three sets of detector coils are mounted inside the turbine: one to measure axial displacement, one to measure vertical eccentricity and displacement, and the third to measure horizontal eccentricity and displacement. The instrument readings then give a clear picture of any distortions taking place in the turbine while it is actually running.

The equipment was specified to be independent of normal variations of voltage or frequency of the electric supply, and to have a degree of reliability of the same order as the turbine set itself.

When this equipment was developed it was found possible to give, in addition to the above measurements, values of the mean position of the shaft with respect to the bearing housing, in both vertical and horizontal directions. Thus the position of the shaft journal with respect to the bearing and its oil film could be determined.

An auxiliary equipment has also been developed, for occasional use during special investigations, which displays to an enlarged scale on the screen of a cathode ray oscilloscope, a polar diagram of the motion of the end of the shaft.

Additional apparatus has been developed in order to measure and record the speed of the turbine, using a small high-frequency alternator driven from the turbine shaft. As the turbine speed increases from rest, the output from the generator is fed directly to the indicating and recording instruments until a speed of about 2,750 rpm is reached. At speeds above this, the output is automatically switched to tuned circuits before being fed to the instruments. Two scales of equal length are provided on the indicator, calibrated 0-3,000 rpm and 2,700-3,300 rpm. The recording instrument shows three ranges covering 0-3,000, 2,700-3,300 and 3,200-3,500 rpm.

ATOMIC POWER STATION

Scientists of the Atomic Energy Research Establishment at Harwell have prepared a theoretical picture illustrating how electricity might be produced in an atom-powered generating station.

It shows how heat from an atom pile could be used to produce steam which, in turn, would drive the dynamos to produce electric current. This method is now being investigated at Harwell.

Scientists estimate that the atomic fuel in such a plant would not have to be replaced for 15 to 30 years, and consumption of coal by British power stations is increasing so rapidly that 13,000,000 more tons may well be required every year by 1950.

In an atomic power station, the present coal and coke furnaces would be replaced by atomic piles. The resultant saving in those fuels, could thus make an important contribution to the country's economy by releasing coal for industry and export. It is expected that an experimental unit will soon be built which will foreshadow the first atomic power station.

PAMETRADA 3,500 S.H.P. MARINE GAS TURBINE

Since publication of the Parsons and Marine Engineering Turbine Research and Development Association Progress Report for the year 1951, on the development at the Pametrada Research Station, Wallsend of the 3,500 S.H.P. Marine Gas Turbine, a 100 hour continuous run at full power has been carried out when the following mean performance figures were achieved.

S.H.P. (corrected to 14·7 lb/sq in. and 60° F)	3532 H.P.
H.P. turbine inlet temperature (corrected to 60° F)	1242° F
L.P. turbine inlet temperature (corrected to 60° F)	1284° F
H.P. turbine speed (corrected to 60° F)	4650 rpm
Thermal Efficiency	27·9%
Fuel Consumption (corrected to 60° F)	505 lb/B.H.P./hr.

After the 100 hour continuous run at full power had been concluded, a complete opening up took place and an inspection was carried out by Lloyds who subsequently produced a very satisfactory report.

During the period of opening up, opportunity was taken to carry out modifications as follows:—

(a) New glands were fitted to the H.P. turbine to reduce sealing air consumption.
(b) A water eliminator was fitted in the discharge side of the intercooler in order to prevent the admission of water to the H.P. compressor, where it caused deposits to adhere to the blading.
(c) An additional row of blading was added to the L.P. Compressor to raise the compression ratio to the designed figure.
(d) Modifications were made to the mixer following the two reheat combustion chambers to reduce temperature variations over the gas stream.

The designed consumption for the gas turbine as originally conceived was ·54 lb/S.H.P./hour. The best figure obtained so far is ·49 lb/S.H.P./hour. As a result of the modifications carried out it is hoped to improve on this figure.

The running to date has been carried out on distillate fuel. As soon as the turbine has been proved after reassembly, running on residual fuels will commence, which should take place shortly.

Progress has been slower than expected due to unforeseen demands on the Research Station's resources by the Admiralty. These demands have now been reduced and the tempo of the Gas Turbine Programme is being speeded up again.

THE UNIFICATION OF ENGINEERING STANDARDS

Copies are now available from the British Standards Institution of the official, 64-page report of the A-B-C (American, British, Canadian) Conference on the Unification of engineering standards, held in New York from 2nd to 5th June.

The A-B-C Unification programme arose out of disastrous and costly wartime experiences due to the limited interchangeability between the Services equipment of the three countries. First step to overcome this difficulty was the 1945 Ottawa conference arranged by the Combined Production and Resources Board. From this arose the "Declaration of Accord," which established a system of Unified screw-threads for sizes of $\frac{1}{4}$ in. diameter and upwards, and was signed by the three nations in 1948.

Exchanges continued and led eventually to invitations for another full-scale conference being sent out earlier this year by Dr. J. R. Steelman, Acting Director of the U.S. Office of Defense Mobilization. The agenda covered five aspects of engineering practice—screw-threads, pipe threads, gas cylinder connections, limits and fits and drawing office practice.

The British team of 25 was led by Mr. Stanley J. Harley, Chairman of the Engineering Divisional Council of B.S.I., who was supported by Mr. S. W. Rawson, Director-General Machine Tools, Ministry of Supply; Sir William Stanier and Mr. H. A. R. Binney, Director of B.S.I. The Americans sent 94 high-level representatives of industry, the services government agencies and standards bodies, and Canada was also fully represented.

The keynote of the conference was set at the opening session on June 2nd, when Mr. Stanley Harley said that the British delegation had come in a somewhat critical spirit—critical of themselves, and of the lack of progress in some of the projects discussed at Ottawa in 1945. To ensure speedy and decisive action the conference split into five Working Committees, each one to deal with a single item on the agenda, and to report back to another full session on June 5th.

In three days of long and late sessions all five Committees made useful progress. Not the least achievement was the clarification of those fields where long-established differences in practice in the three countries made it impossible for their national standards to be altered. Frank recognition of these conditions cleared the way for productive discussion and decision on other matters.

The range of agreement reached on acme and buttress threads, on limits and fits and on drawing office practice is set out in the published report now available.

"Continuing Committees," with representatives from all three countries on each, were set up to progress the work started at the conference. The British members of these Committees are:—

Screw-threads: Mr. S. W. Rawson, Ministry of Supply (Chairman) and Mr. F. H. Rolt, National Physical Laboratory.

Pipe threads: Dr. J. S. Blair, Stewarts & Lloyds Ltd.

Gas Cylinder connections: Mr. N. R. K. Wheatley, Ministry of Supply.

Limits and Fits: Mr. H. G. Conway, British Messier Ltd.

Drawing office practice: Mr. T. R. Houston, English Electric Co. Ltd.

A further progress meeting in New York is planned for mid-October.

In the meantime arrangements are far advanced for the signing of formal agreements under which the Unified screw-thread will become the standard for the armies of all the A-B-C countries. Many of the American manufacturers concerned in the production of services equipment have already turned over to the Unified thread, and it is steadily being adopted both in Canada and the United Kingdom.

HIGH-SPEED DRY DOCK FOR AIRLINERS

The period when the airliner is in " dry dock " for its periodic maintenance overhaul is one which every operator wants cut to a minimum.

This has been done by platform structures built up round the 'plane so that the maximum number of engineers can work on it simultaneously. The docks are pre-fabricated so that they can be easily packed up and transported to an overhaul base abroad.

They are metal platforms—some static, some mobile—designed so that the engineers can get to all the main inspection points from the nose-wheel tyre to the tip of the tail fin. Each has its built-in supply of electricity, compressed air, hydraulics, lighting, fire-fighting equipment and other services—right down to clothing lockers for the engineers' overalls.

The platforms have non-skid floors, and each is carefully planned to give the engineers maximum working room at each inspection point.

Two pre-fabricated dry docks have recently been designed by Tiltman Langley Laboratories.

One is for British European Airways *Pionair* aircraft. It is a series of mobile stands which can be quickly pushed into position round the aircraft as soon as it is in the maintenance hanger.

The other is a somewhat more complicated dock for larger airliners made so that it can be fixed to the hanger floor. Its working platforms completely surround the aircraft, except for two moveable sections around the nose, so that the maintenance engineers can walk right round the aircraft at various platform levels.

The docks are in pre-fabricated sections designed with the so-called Keylock system. It consists of a number of extruded aluminium-alloy channels which are made up into the required lengths and shapes and put together by locking pairs of precision slots. They are kept rigid and locked by tapping a tapered pin through a hole in each section.

Complex structures can be built up without any tools other than a hammer. The structure can be knocked down again for transporting it to another maintenance base, simply by knocking out the series of key-pins.

The same system can be used to build dry docks for the biggest airliners; there is no limit to size.

BOOKS

Turbine a Gas (Gas Turbines). By Professor V. Rubbo. 2nd edn. (revised & enlarged), 1952, 401 pp., 228 figs. Edizioni Bignami, publishers, Milan, Italy. Price: Lire 5500.

This is not merely a revised edition but practically a new book on gas turbines of recent types. The chapters on axial compressors, centrifugal compressors, and turbine components, have been entirely rewritten, those dealing with open and closed cycle installations and other applications have been considerably expanded and brought up to date, and the chapters on thermodynamics and gas turbine materials have been approximately trebled in size. The book includes calculations of theoretical and practical turbine cycles, applications of the theory of similarity, design principles, calculations of blade stresses, etc., as well as descriptions of combustion chambers, heat exchangers, regulating devices, and an extensive collection of tabular data on the creep properties, fatigue strength and other properties of turbine alloys. Numerical examples of calculations are also given. The last two chapters review various gas turbine designs evolved in recent years in Great Britain, the United States, Switzerland, France, Germany, and other countries. Altogether [illegible] bibliographic references are given.

Hydr[illegible] the Mechanics of Fluids. By E. H. Lewitt. 9th edn. [illegible]. 297 figs. Publishers: Sir Isaac Pitman & Sons Ltd., Pa[illegible]treet, Kingsway, London, W.C.2. Price: 25/-.

Lew[illegible]ook is well known to students and engineers concerned with h[illegible]ics and its applications. This new, 9th edition, contains a [illegible]w chapter on Flow of Gases through Pipes. As a folding insert, a chart is inserted from which the results for the adiabatic flow of air can be read off directly.

Hydraulics and its Applications. By Professor A. H. Gibson. 5th edn. 813 pp. 427 figs. Publishers: Constable & Co. Ltd., 10 Orange Street, London, W.C.2. Price: 35/-.

Production and Inventory Control. By William E. Ritchie. 278 pp. 109 figs. Publishers: The Ronald Press Company, 15 E 26th Street, New York 10, N.Y. Price: £5.00.

BRITISH STANDARDS

(Copies of British Standards may be obtained from the British Standards Institution, 24, Victoria Street, London, S.W.1)

Flanged Steel Globe Valves for the Petroleum Industry. B.S. 1873 : 1952 covers cast or forged steel outside-screw-and-yoke globe valves with integral flanges and ball or plug type disks, the seat rings being renewable and either shoulder-seated or bottom-seated. The permissible pressure is a maximum of 1000 lb./sq. in. for valves of class 300 and above for valves ¼-8 in. size.

The standard includes provisions relating to design and manufacture, materials, workmanship, marking, tests, inspection, despatch and guarantee.

The specification is supported by a number of appendices and two detailed drawings illustrating the valves covered and providing identification of the various parts of the valves. Price 10/-.

Rolled Copper Sheet and Strip for General Purposes. B.S. 899 : 1952 includes provisions for annealed, half hard and hard conditions, the mechanical properties have been modified and elongation requirements have been added, as well as an embrittlement test for deoxidized material. Other minor amendments have been made in order to bring the standard as far as possible into line with the revised edition of B.S. 1432, " Copper for electrical purposes (sheet and strip) " which will be issued shortly. Price 2/6.

Classified Advertisements.

The rate for all classified advertisements is 6d. per word; in bold print 9d. per word; minimum order 6s. Box number advertisements 1s. extra. Instructions together with remittance must be received not later than the 3rd of each month for advertisements to appear in the same month's issue.

SITUATIONS VACANT

THE BRITISH DRIVER-HARRIS COMPANY LTD. invite applications for the following positions in their U.K. organisation from young men who have completed their National Service. The positions are permanent and pensionable.

(a) Young men of about 20 years to be trained as inside and/or outside salesmen. No previous experience is necessary but applicants must have had a good general education.

(b) Costing Clerks with experience of the products of this Company desirable but not essential.

(c) Technical men of at least ordinary Degree standard or equivalent, to conduct investigations into problems of manufacture and application of Nickel and its alloys and co-related subjects. Spectrograph experience an advantage but not essential.

Applicants should write fully to the Secretary, Gaythorn Mill, Albion Street, Manchester, 15.

A WELL KNOWN FIRM developing a revolutionary electrical engineering technique, wishes to engage a resourceful **Electrical Engineer** with sound theoretical background. Excellent prospects for right man. Write giving full particulars and salary required.—Box R 159.

SITUATIONS WANTED

MECHANICAL ENGINEER (42) honours degree, A.M.I.Mech.E., A.F.R.Ae.S., returning from a two-years contract as Project Engineer overseas, desires a responsible and progressive appointment in the London area, preferably one offering frequent missions abroad. Successful record and extensive experience at home and abroad, embracing Gen. Mech. Eng., Spec. Machine Design, Compressors, Turbines and Aircraft. Executive and organizing ability. Previous salary a four-figure one. Box H.1.

APPOINTMENTS

THE INSTITUTE OF EXECUTIVE ENGINEERS and Officers maintains an Appointments Register for its members and welcomes applications from students and other administrative, executive and technical engineers and officers for membership.—Full details will be forwarded on request, upon giving age, appointment held, particulars of industry or Government Department, to the Secretary, Executive Chambers, 241, Bristol Road, Birmingham, 5. E2849 E

WORK WANTED

REPETITION WORK. Auto capacity on 10 M.M. Wickman Capstan Work in all materials. Good deliveries. **Whittaker Bros. (Shaw) Ltd.,** Shaw, Lancs. Tel.: Shaw 7475.

BOTTLENECK IN CASTINGS ? We can probably help you. Small part of our capacity available at the moment for precision, aluminium gravity die castings, zinc pressure die castings. High standard of workmanship; established 1828. Write or 'Phone **Thos. Ashworth & Co. Ltd.** (Dept. E.D.5) Vulcan Works, Burnley, Lancs. (Burnley 5259, 4 lines).

MACHINERY, ETC., FOR SALE

MASSEELEY Stamping Machines and supplies. **Hill Bros. Ltd.,** Beaconsfield Road, London, W.4

The **VAPOR PHASE** cooling system fitted to ANY DIESEL or INTERNAL COMBUSTION ENGINE will provide factory heating or process steam, at NO cost for fuel, besides lengthening the life of the engine. VAPOR PHASE recovers waste heat as live steam, pays for itself in the first year, costs nothing to operate and is good for life. Send for leaflet VP.127, **Bastian & Allen Ltd.,** Ferndale Terrace, Harrow, Middlesex. Tel.: HARROW 7171.

FULL STEAM IN FIVE MINUTES with B & A Electrode Boilers, used by British industries for 20 years. No boilerhouse, no flue, no attendant needed. The most compact and convenient steam raisers available, can go beside machines using the steam. Write for leaflet 127, **Bastian and Allen Ltd.,** Ferndale Terrace, Harrow, Middlesex.

RECONDITIONED EX-ARMY HUTS, and manufactured buildings. Timber, Asbestos, Nissen Type, Hall Type, etc. All sizes and prices. Write, call or telephone—**Universal Supplies (Belvedere) Ltd.,** Dept. 50, Crabtree Manorway, Belvedere, Kent. Tel.: ERITH 2948.

MISCELLANEOUS

WANTED.—Complete 1940 and 1941 volumes of " The Engineers' Digest " at double of original subscription price. Also Jan., Febr. and March, 1952, issues at 3/6 per copy.—Subscription Dept., 120, Wigmore Street, London, W.1.